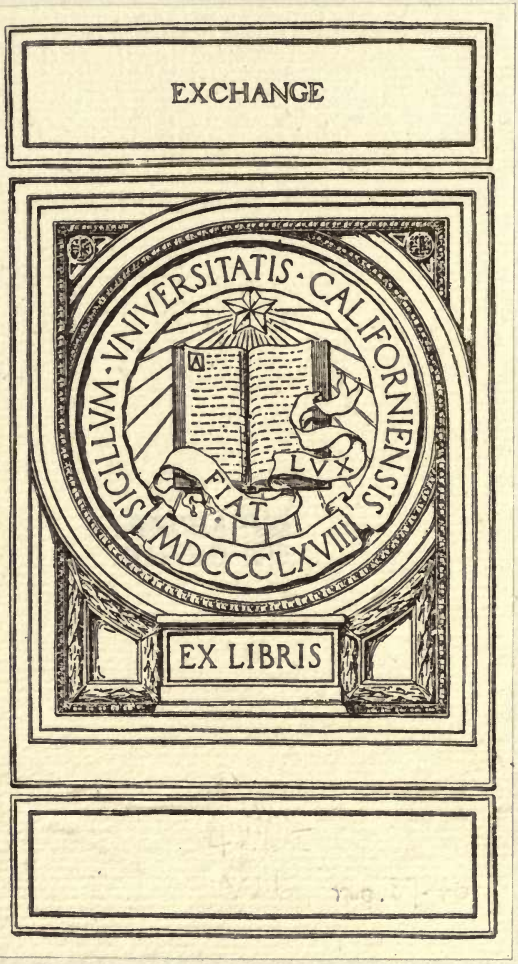

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SOIL SURVEY IN COOPERATION WITH THE COLLEGE OF AGRICULTURE
H. L. RUSSELL, DEAN

BULLETIN NO. XXXVII SOIL SERIES NO. 7

SOIL SURVEY

OF

FOND DU LAC COUNTY

WISCONSIN

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UNITED STATES DEPARTMENT OF AGRICULTURE,

SURVEY CONDUCTED IN COOPERATION WITH THE UNITED STATES
DEPARTMENT OF AGRICULTURE, BUREAU OF SOILS,
MILTON WHITNEY, CHIEF.
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MADISON, WIS.
PUBLISHED BY THE STATE
1914

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TABLE OF CONTENTS

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

SUMMARY.

ILLUSTRATIONS

PLATES AND FIGURES.

MAP

INTRODUCTION

Before the greatest success in agriculture can be reached, it is necessary that the farmer should have a thorough knowledge of the soil upon his own farm. A soil may be well adapted to one crop, and poorly adapted to another crop. Clover will produce a vigorous growth and profitable yields on the average loam soil which contains lime and is in a sweet condition; but on a sandy soil which is sour, or in an acid condition, clover will not make a satisfactory growth. We may say, therefore, that failure is certain to be invited when such important facts are disregarded, or overlooked. The degree of success which it is possible to win on any farm is in direct proportion to the practical knowledge possessed by the farmer concerning the soil and its adaptation to crops. A thorough knowledge of the soil is as essential to the farmer as a knowledge of merchandise and business methods is to the merchant.

The State of Wisconsin, working in coöperation with the United States Department of Agriculture, is making a careful study of soils and agricultural conditions throughout Wisconsin, and is preparing soil maps and soil reports of all counties in the State. A soil map shows the location and extent of the different kinds of soil. Tracts of 10 acres and over are mapped, but often areas of even smaller extent are shown. The soil map is prepared by trained men, who go over a county thoroughly, and examine the soil by making a sufficient number of borings to a depth of 36 inches to keep account of all variations. A report is also made, to accompany and explain the map, and this is based upon a careful study of the soils within the region surveyed, and upon such other features as have a direct bearing upon the agriculture of the area.

It is the object of this survey to make an inventory of the

soils of the State, and to be of practical help to farmers by locating and describing the different soils, by determining their physical character and chemical composition, and by offering suggestions for their management, based upon the work of the Soil Survey within the area, covered in the report, and upon the results of field tests made by the Experiment Station.

Soil fertility depends upon two factors: first, upon the physical characteristics of the soil, such as water holding capacity, workability, etc., and second, upon the chemical composition of the material composing the soil. The chemical composition depends upon the mode of origin of the soil, and the source of material from which the soil is derived.

Water holding capacity, and other physical properties of soil all depend chiefly upon *texture,* which refers to the size of the individual soil grains, or particles. A coarse sandy soil, for example, will not retain moisture so long as a loam soil, or clay loam, because the finer the soil grains, the greater will be the total soil-grain surface area to which moisture may adhere. Texture is determined in the field by rubbing the soil between the thumb and fingers, and with experience one soon becomes expert at judging the size of soil grains. This field judgment is verified in the laboratory by a *mechanical analysis,* which is made by a simple method of separating soil grains into different groups, of which there are seven. These are known as clay, silt, very fine sand, fine sand, medium sand, coarse sand, and fine gravel.

A chemical analysis is also made of the soil to determine the amounts of various essential plant-food elements which are present. A chemical analysis shows whether the soil contains a large store of plant food, or only a small quantity, and it indicates which kinds of plant food will probably be needed first. The amount of organic matter in the soil is also determined, and tests are made to show conditions relative to soil acidity.

SOIL CLASSIFICATION.

Soils are grouped according to texture into soil classes, a *soil class* being made up of soils having the same texture, though differing in other respects. A fine sand, for example, may be light colored and of alluvial origin, while another fine sand may be dark in color and of residual origin, while a third fine sand may have been blown into sand dumes by the wind, yet all of these soils would belong to the same class, because the greater proportion of the soil grains have the same size or texture. Thus we may have different kinds of clays, loams, sands, etc., and the class to which any soil will belong depends upon the size of the individual soil grains of which it is composed, and not upon its color, origin, topographic position, or agricultural value.

SOIL CLASSES

Soils Containing Less Than 20% Silt and Clay

Coarse sand.—Over 25% fine gravel and coarse sand, and less than 50% of any other grade of sand.
Sand.—Over 25% fine gravel, coarse and medium sand, and less than 50% fine sand.
Fine sand.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.
Very fine sand.—Over 50% very fine sand.

Soils Containing Between 20–50% of Silt and Clay

Sandy loam.—Over 25% fine gravel, coarse and medium sand.
Fine sandy loam.—Over 50% fine sand, or less than 25% fine gravel, coarse and medium sand.
Sandy clay.—Less than 20% silt.

Soils Containing over 50% of Silt and Clay

Loam.—Less than 20% clay, and less than 50% silt.
Silt loam.—Less than 20% clay, and over 50% silt.
Clay loam.—Between 20 and 30% clay, and less than 50% silt.
Silty clay loam.—Between 20 and 30% clay, and over 50% silt.
Clay.—Over 30% clay.

Soils may be grouped in another way. Where soils are closely related through similar sources of the material from which derived, mode of origin, topographic position, etc., so that the different soils constitute merely a graduation in texture of otherwise uniform material, such a group is called a *soil series*. It corresponds to the family which is made up of different in-

dividuals having the same parentage. The Miami series, for examples, includes light colored, glacial material where the soils have been derived largely from the underlying limestone, and the soils in the series range in texture from a clay loam to sand and gravel. The Plainfield series includes light colored soils in regions where no limestone is present, where the parent rock was largely sandstone, and where the material occurs as outwash plains or stream terraces. The soils in this series also have a wide range in texture. The name used for a soil series usually indicates the locality where that particular series was first recognized and mapped by the Soil Survey.

By uniting the name of the *soil class,* which refers to texture, with the name of the *soil series,* which refers chiefly to origin, we get the *soil type,* which is the basis or unit of classifying and mapping soils. A *soil type,* thus, is a soil which is uniform throughout its entire extent in texture, color, topographic position, and other physical properties, and having a distinct agricultural unity, that is, being adapted to the same crops, and requiring the same treatment. It is also uniform in the source of material from which it is derived, and the mode of origin which, taken together, determine the chemical composition. Since the soil type is the unit in classifying and mapping soils, and the basis upon which experimental work should be conducted, every farmer should be familiar with the soil types on his farm, and their leading characteristics.

SOIL SURVEY OF FOND DU LAC COUNTY, WISCONSIN.

CHAPTER I.

GENERAL DESCRIPTION OF AREA.

Fond du Lac County is located a little to the south of the east-central part of Wisconsin. It is bounded on the north by Winnebago and Calumet Counties and Lake Winnebago, on the east by Calumet and Sheboygan Counties, on the south by Washington and Dodge Counties, and on the west by Green Lake County. The county is 36 miles long and varies in width from 27¼ miles in the eastern one-third to 18 miles in the western two-thirds of the county. It has an area of approximately 734 square miles, or 469,760 acres. The east county boundary is from 19 to 23 miles from Lake Michigan.

The most pronounced topographic feature in the county is an escarpment of Niagara limestone, which extends across the area from northeast to southwest. It first appears about 1½ miles south of Pipe, extending southward to a point about 7 miles below Taycheedah, where it swings westward past Hamilton and on to Oakfield, passing out of the county to the southwest. It is not continuous throughout its course, although there are unbroken stretches of several miles. This escarpment varies in elevation from 50 to 150 feet above the general level of the country below. Fond du Lac, which is situated but a short distance from the foot of the escarpment, has an elevation of 760 feet above sea level.

To the east of the escarpment the surface is higher and more rolling than to the west. The Kettle Moraine crosses the southeastern part of the county, and throughout this region the topo-

graphy is rolling to hilly, with numerous kettle holes, gravelly ridges, and other evidences of glacial action. North of this section the surface is gently rolling to rolling, with numerous drumlins and a few level areas of relatively small extent.

Immediately to the west of the escarpment is a large flat area of excellent soil, at one time occupied by an extension of Lake Winnebago. This extends southward to within a few miles of the county line. Between this old lake basin and the west county line is another extensive area of excellent farming land. The surface varies from nearly level to undulating and gently rolling. A large proportion of this region was originally prairie land, and has a rich black soil, while the remainder consists of a light-colored soil, formerly carrying a good stand of timber. Numerous marshes, varying in size from a few acres to over 10 square miles in extent, are scattered throughout the county both east and west of the escarpment.

The drainage of the county is somewhat unusual in that a number of fair-sized rivers have their headwaters within its boundaries. The greater proportion of the eastern part of the survey above the escarpment drains into Lake Michigan through the South Branch of Manitowoc River, Sheboygan River, and the West and Middle Branches of Milwaukee River. All of these streams rise in the county. The stretch of level country in the central part of the area, extending from Fond du Lac nearly to Oak Center, drains through the East Branch of the Fond du Lac River into Lake Winnebago. The West Branch of the Fond du Lac River drains the north-central part of the county. A few smaller streams flow directly into Lake Winnebago and drain a narrow margin along the east and west shores of the lake. The extreme northwestern corner is drained by Silver Creek and the west-central part by Grand River, both of which empty into the Fox River, and thence into Lake Winnebago. The headwaters of Rock River drain the southwestern and south-central parts of the county. This stream flows into the Mississippi River, and the region drained by it is the only part of Fond du Lac County whose drainage waters do not finally reach Lake Michigan.

The first settlement in the county was made on the present site of Fond du Lac in 1836. Farming operations started in Fond

du Lac Township in 1837 and in Waupun in 1839. The real settlement of the county, however, began in 1844–45, when many farms were opened up.

Some of the early settlers were French from Canada, many came from New England and other eastern States, while some came directly from European countries. In the southeastern part of the county Germans and Irish predominate at the present time. In the vicinity of Eden and to the east the Irish are the most numerous. In the northeastern part Germans and a few French are found. The central and western parts of the survey are settled mostly by descendants of German families. All portions of the county are well settled and highly developed agriculturally.

Fond du Lac, with a population of 18,797, is the largest city in the area, the county seat, an important railroad point, and a prominent manufacturing center. It is situated at the southern end of Lake Winnebago and is surrounded by an excellent farming country. Ripon, in the northwestern corner of the county, with a population of 3,739, is located in the center of a rich agricultural region and is a thriving, modern town. Waupun, in the southwestern part of the county, has a population of 3,362, is surrounded by excellent farming land, and is the center of a highly developed community. Brandon, Oakfield, Oak Center, Campbellsport, Eden, Rosendale, Vandyne, Fairwater, and St. Cloud are smaller towns and villages.

Three important railroad systems traverse the county and provide excellent transportation facilities for all sections. These lines are the Minneapolis, St Paul & Saulte Ste. Marie Railway, The Chicago, Milwaukee & St. Paul Railway, and the Chicago & Northwestern Railway.

Fond du Lac has water connection with points on the Great Lakes through Lake Winnebago, the Fox River, and Green Bay, though the large lake boats can not come into Lake Winnebago. This makes the use of smaller boats necessary from Green Bay to Fond du Lac.

Fond du Lac and the other towns within the area provide a market for considerable farm produce and supply shipping points from which large quantities of produce reach outside markets. Chicago, over the Soo Line, is 159 miles, and Milwaukee, over the Northwestern, 63 miles distant.

Most of the wagon roads throughout the county are graded, and many miles are surfaced with crushed rock and gravel. As a whole the public highways are kept in very good condition. All parts of the county have rural free delivery mail service, and telephones are in common use throughout the country districts.

SOILS.

Fully 95 percent of the land surface of Fond du Lac County is covered by glacial material, which is known geologically as The Late Wisconsin Drift, and from this formation the soils of the region have been derived. While there are a number of rock formations exposed within the survey, there are no soils in the county, of sufficient extent to map, which have been derived from the residual decay of these rocks. Limestone formations are the most extensive appearing as surface rock in Fond du Lac County, and material from this source has entered largely into the formation of the glacial debris covering this region. In the western half of the county the surface material appears to have some of the characteristics of loess and may have been deposited in part by wind action.

Outcrops of Potsdam sandstone, Lower Magnesian limestone, and St. Peters sandstone are found in the vicinity of Ripon, but contribute only very slightly to the material from which the soils of this neighborhood are derived. To the south and east of Ripon occur outcrops of Trenton limestone. The eroded remnants of the more indurated portion of this formation give rise to the rounded hills and knolls, covered with irregular limestone fragments, so conspicuous in this section of the county.

Bordering the Trenton limestone on the east and south is the Galena limestone, which outcrops prominently south of Rosendale and around Waupun, where it is quarried for road material. It is also found as rounded knolls covered only with a thin mantle of soil. Overlying the Galena limestone is the Cincinnati shale, which is exposed slightly just below the escarpment mentioned in the description of the topography of the county. Overlying this is the Niagara limestone found in the cliffs along the east shore of Lake Winnebago and extending to the south and south-

west as a series of rock outcrops forming a ledge varying in height from 50 to 150 feet.

While all the soils of this region have been derived from glacial debris, this material has been modified in various ways since its first deposition. Some of the soil was washed into glacial lakes and now appears as lake laid or lacistrine material. Some material was deposited by water as it escaped from beneath the glacial ice sheet, and is now known as outwash plains. The glacial debris also occurs as elongated hills known as drumlins, as small, rounded, gravelly hills known as kames, as long, narrow, winding gravelly and sandy ridges known as eskers, and as more rolling and broken country included in the Kettle Moraine. The greater proportion of the surface material, however, occurs as undulating to gently rolling country known as the ground moraine. The action of the wind, water, and weathering, and the accumulations of organic matter have also modified the surface material since its first deposition. The Soil Survey has classified this material into 7 soil series and 15 soil types* all of which have peculiar characteristics by which they can be recognized.

The Miami series, which is by far the most extensive series in the county, comprises the light-colored glacial soils occupying the undulating to slightly rolling ground moraine throughout most of the county, and the rougher Kettle moraine in the southeastern part of the survey. All the members of this series were originally timbered. The soil material contains considerable finely ground limestone, and in places coarser limestone fragments. Three types, the Miami silt loam, gravelly loam, and sandy loam, were recognized and mapped as belonging to this series.

The Fox soils are formed of light-colored glacial material occupying overwash plains or old, filled-in valleys in which the material has been modified more or less by water action. But one type, the Fox silt loam, was mapped.

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* The Miami silt loam as described in this report includes what was first mapped, and described in the Bureau of Soil's edition of the Fond du Lac County Report as Miami silt loam, and Miami silt loam, deep phase.

The Clyde clay loam covered by this report includes what was previously described as Clyde silty clay loam, and Clyde silt loam.

The Superior clay loam includes what was previously mapped as Superior silty clay loam, till phase.

The Superior clay loam, rolling phase, includes what was previously mapped and described by the Bureau of Soils as Kewaunee clay loam.

The Superior series is made up of soils composed largely of lacustrine, or lake laid, material carrying only a comparatively small amount of organic matter, and having a characteristic red or pinkish-red color. The surface of the typical soil is level and the natural drainage is poor. In some places where glacial action or erosion has modified the surface so that the drainage is fair or good the material is classed as a rolling phase of the Superior. The rolling phase usually contains more stones and gravel than the typical soil. The two types in the Superior series were mapped Superior clay loam, with its rolling phase, and Superior gravelly loam.

The Poygan series represents a lacustrine deposit similar to the Superior, but with which a considerable amount of organic matter has become incorporated through the decay of vegetation under moist conditions. This has resulted in a black surface soil, beneath which the red clay of the Superior is found. It is closely associated with the Superior series, but occupies a slightly lower level. Two types, the Poygan clay and the fine sandy loam, were mapped as belonging to this series.

The Carrington series comprises the dark-colored prairie soils derived from glacial till. It is confined to the western part of the county. Two types, the Carrington silt loam and the gravelly loam, were mapped.

The Clyde series occupies old lake beds, ponded valleys, and the valleys of present-day streams where there has been an accumulation of organic matter in quantities not sufficient to form Muck or Peat. Two types the Clyde clay loam, and fine sand, were recognized.

Another group of soils has been given the name Rodman. The surface material of this series varies in color from different shades of light brown to yellow. They are frequently made gray by the presence of organic matter, and in some cases have a slight reddish cast. The material is found as eskers and kames, and has therefore been formed within or underneath the glacial ice. While this material has been assorted, stratification or cross bedding is in many places indefinite. Two types of this series were mapped, the gravelly sand and the gravel.

Peat, with included areas of Muck, occupies old lake beds, ponded valleys, etc., where there has been a great accumulation

of vegetable matter in various stages of decomposition, but with which there is only a comparatively small amount of mineral matter.

The following table gives the actual and relative extent of the several soils mapped in the survey of Fond du Lac County:

Areas of different soils.

Soil	Acres	Per cent.	Soil	Acres	Per cent.
Miami silt loam	178,723	38.0	Rodman gravel	4,480	1.0
Peat (with included areas of Muck)	62,720	13.3	Carrington gravelly loam	1,920	.4
Clyde clay loam	54,976	11.7	Superior gravelly loam	1,280	.3
Carrington silt loam	46,592	9.9	Miami sandy loam	1,280	.3
Miami gravelly loam	45,184	9.6	Clyde fine sand	896	.2
Superior clay loam	8,064	7.2	Rodman gravelly sand	640	.1
Superior clay loam, rolling phase	25,728		Poygan fine sandy loam	320	.1
Poygan clay	28,096	6.0	Total	469,760	.....
Fox silt loam	8,832	1.9			

CHAPTER II.

GROUP OF HEAVY, LIGHT-COLORED SOILS.

MIAMI SILT LOAM.

Description.—The surface soil of the Miami silt loam consists of a friable silt loam extending to an average depth of 10 inches. The silt content is high and the soil has a smooth feel. When moist the color is a grayish-brown, but when dry it frequently has an ashy appearance. The light color of the type is indicative of a low organic-matter content.

The subsoil consists of a light-yellow silty clay loam, in which the clay content increases with depth until a yellowish-brown heavy clay loam or chocolate-brown clay loam is encountered at a depth of 20 to 26 inches. This material frequently extends to more than 3 feet, though at depths ranging from 2 to 4 feet a gritty clay loam or gravelly material is usually encountered. This mixture of clay, sand, gravel, and bowlders is true glacial till, and extends to a depth of 10 to 25 feet.

Where the topography is level or gently rolling, the gritty material lies at a greater depth than is the case on the slopes of hills and ridges. In the latter the silty covering has been partly removed by erosion and the silty clay loam exposed over areas of limited extent. Underlying this mantle the gravelly material and occasional beds of sand, are found within reach of the 3-foot auger. This is especially true in the southeastern part of the county, where the soil and subsoil sometimes contain small quantities of fine sand, with some gravel on the surface. Bowlders and pockets of gravel occur in some sections and in places the stones are so numerous that the fences have been made of them. Wherever the bed rock comes close to the surface the subsoil directly over the rock is heavier than where it is underlain by the gravelly material.

An important phase of this type was found quite extensively associated with the typical soil, and this is referred to as the deep phase. It differs from the typical soil by having a somewhat higher percentage of silt in both soil and subsoil, and the section free from coarse material extends to a greater depth than in the typical soil. The surface of the deep phase is usually not so uneven as that of the typical soil; it is practically stone free, and there is a very sharp line of demarcation between the upper, silty section, and the underlying bed of true glacial till. Where the phase borders the Carrington silt loam the soil and subsoil are of a darker color than the typical. This border phase is considered the best soil in the county. Adjacent to the Clyde clay loam the surface is also darker, except in a few instances, where a light ashy gray surface soil is found. This is apparently the Clyde clay loam, from which a covering of peat has been burned off. Because of the irregularity of the occurrence of the deep phase, and because there is never a definite line between this and the typical soil, no attempt was made to indicate the differences on the soil map.

Extent and distribution.—The Miami silt loam is the most extensive and important type of soil in Fond du Lac County, and covers 38 percent of the area. It is the predominating type throughout the eastern portion of the survey where it is associated with other soils of the same series. This extensive region of Miami soils on the east is separated from other areas of Miami silt loam in the western part of the county by the limestone ledge or escarpment running through the survey, and the extensive body of Poygan and Superior soils occupying the flat country south and west from Fond du Lac. In the western portion the Miami silt loam is closely associated with the Carrington silt loam. The typical soil predominates in the eastern portion of the county, while in the western part the deep phase predominates, though either may be found both in the east and in the west, depending chiefly upon the topography.

Topography and drainage.—The typical soil occupies the tops and lower slopes of drumlins, kames, and glacial ridges, the more gently rolling land intervening, and in a few places small areas of nearly level land. The surface may be classed as rolling to hilly with some gently rolling tracts. Where the deep phase

predominates the surface varies from undulating to gently rolling. This condition prevails throughout most of the western section of the county, while the typical soil, and the more broken topography is confined chiefly to the eastern portion. Where the slopes are steep in areas of typical soil some erosion takes place, but no large areas have been damaged in this way. The natural drainage is good over most of the type, but on the nearly level to undulating tracts tile drains could be used to advantage in many places.

Origin.—The material composing this type is derived from the weathering of glacial drift that occurs chiefly as ground moraine. Limestone constitutes the predominating stony material throughout the soil, but in spite of this fact much of the lime has been removed from the surface by leaching and a slightly acid condition is found to exist in places as indicated by the litmus test.*

The origin of the deep phase differs from that of the typical soil by having a covering of loess-like material over the true glacial till. It frequently has a laminated structure, but differs from a typical loess stratum in its rather heavy subsoil. It seems probable that the extremely silty surface material in both the deep phase and the typical soil owes its origin in part at least to the action of the wind. This wind influence, however, appears to have been much more pronounced in the formation of the deep phase.

Native vegetation.—The timber growth on this type was rather heavy, consisting of several varieties of oak, ash, hickory, basswood, maple, wild cherry, and elm. At present practically all of the merchantable timber has been removed, only small wood-

* As a number of the soils in this area are in an acid condition and would be greatly benefited by the application of lime, every farmer should know how to test his soil for acidity. "A very simple and reliable method to detect soil acidity is by the use of blue litmus paper, which can be secured of any good druggist. Take a handful of moist soil and form it into a ball. Break the ball into halves and place a piece of blue litmus paper in the center on one of the halves, and cover over with the other half. After 5 minutes break the ball, and if the paper is pink in spots or over the whole end, the soil is acid." "Soil acidity is also usually indicated by the growth of certain weeds, such as sheep sorrel, horse-tail rush, corn spurry and wood horse-tail." For more information on this subject see Bulletin 230 of the Wisconsin Agricultural Experiment Station.

VIEW OF MIAMI SILT LOAM EAST OF RIPON, SHOWING CHARACTERISTIC TOPOGRAPHY, TYPICAL BUILDINGS, AND HIGHLY IMPROVED FIELDS.

General farming and dairying are the leading types of agriculture. This is the most extensive type of soil in the area, there being over 175,000 acres in Fond du Lac County.

lots remaining. The largest forested areas are found on the roughest lands. The timber growth on the deep phase was not nearly as dense as on the typical soil, and the open forest which such land originally supported was spoken of as "oak openings."

*Present agricultural development.**—A very large proportion of Miami silt loam is improved and highly developed. All of the general farm crops common to this region and some special crops are grown. The type of farming followed consists of dairying in conjunction with general farming. In the eastern part corn ranges from 30 to 55 bushels, with an average of 45 bushels, oats from 35 to 50 bushels, barley from 25 to 40 bushels, and wheat from 15 to 25 bushels per acre. Timothy and clover are grown more extensively for hay than other legumes or grasses and produce hay of excellent quality. Some trouble is reported in getting a good stand of clover because of winter-killing, and many farmers consequently use timothy alone.

Alfalfa is being grown by a number of farmers and is coming to be an important crop, though the acreage is not equal to that of clover. Sweet clover grows in many parts of the county and in such places it is probable that no inoculation would be necessary. The soil seems fairly well adapted to alfalfa and the acreage is gradually increasing.

In the cultivation of this type fall plowing is quite common, though because of its friable structure the soil can be worked early in the spring. The subsoil is retentive of moisture and the ease with which a good surface mulch is obtained makes it well suited to resist drought. Barnyard manure is the only fertilizer used extensively, and as dairying is extensively practiced a good supply is always available. From 10 to 15 loads per acre are usually applied every four or five years. It is customary to apply it on sod land to be plowed for corn. Green manuring crops are used to a small extent, though the practice is not common.

Plowing and subsequent cultivation, such as harrowing and disking, are not difficult, since the soil is very silty and pulverizes more readily than a clay. Where the subsoil is exposed on slopes or where the surface covering is shallow and

* For chemical composition and improvement of this soil see page 30.

the heavier material is turned up by the plow, some difficulty is experienced in cultivation.

The rotation of crops most commonly followed consists of corn one year, barley and oats one year each, followed by timothy and clover mixed. Where wheat is grown it may take the place of either oats or barley or it may be made another step in the rotation. The grass is usually left for two years, being cut for hay the first year, sometimes for two years, and pastured one year. Where there is considerable permanent pasture land such as is provided by Marsh and Clyde clay loam, the upland soil is used very little for pasture.

Among the special crops grown on this type sugar beets may be mentioned as receiving considerable attention, especially in the vicinity of Campbellsport. Yields range from 12 to 15 tons per acre and the sugar content is high. Because of the silty nature of the soil and its friable condition it is comparatively easy to maintain a good surface mulch and the work of cultivating the crop is less arduous than on the heavier types.

Irish potatoes are not grown extensively, although most farmers produce enough for home use and frequently have some to sell. The yield ranges from 150 to 200 bushels per acre and the quality is good.

The deep phase as a whole is more productive than the typical soil. The yield of corn varies from 30 to 70 bushels per acre, barley from 25 to 45 bushels, oats from 35 to 70 bushels, wheat from 15 to 30 bushels, and potatoes from 150 to 200 bushels. Alfalfa yields from 2½ to 4 tons per acre and clover and timothy from 1 to 2½ tons.

The type of farming is essentially the same as that on the typical soil, except that on account of the smoother topography and the somewhat higher fertility the growing of grain for market is practiced more than on the main type. While the sugar beet is a special crop on the type, it is not grown to any marked extent on the deep phase; the growing of peas, however, for canning receives some attention.

The following table gives the average results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Miami silt loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil.....	0.2	0.7	0.7	2.2	12.1	68.1	15.8
Subsoil.....	.2	.6	0.9	2.8	9.9	54.3	31.1

FOX SILT LOAM.

Description.—The surface soil of the Fox silt loam conists of an extremely smooth, ashy-gray silt loam, of floury feel, extending to an average depth of 12 inches. Below the surface 3 or 4 inches the soil is slightly lighter in color, but the texture continues uniform. No coarse particles are found in the surface soil.

The subsoil to a depth of 24 to 34 inches grades from a light yellowish-brown silt loam through a silty clay loam into a chocolate-brown, compact clay loam, becoming somewhat gritty in the lower portion. Beneath this occurs a bed of stratified gravel from 10 to 12 feet thick, in which there is but little sand or finer particles. In some places the gravel may come to within a foot of the surface, but usually it lies from 20 to 36 inches below the surface.

Extent and distribution.—The Fox silt loam occupies a total area of 8,832 acres or approximately 2 per cent of the county. It is found in the eastern part of the survey and is confined chiefly to Ashford, Osceola, Eden, Forest and Marshfield Townships. The largest single tract is in Marshfield Township, where it extends over a broad, level plain, surrounded by rolling areas of Miami gravelly loam and Rodman gravel.

Topography and drainage.—The surface of the type is undulating to level. Because of the underlying bed of gravel, the drainage is good and the excess water from heavy rains soon escapes. On the other hand, the soil is sufficiently heavy to retain moisture for growing crops and the type does not suffer from drought except in places where the gravel comes close to the surface or during long-continued dry spells.

Origin.—The soil, though of glacial origin, has been modified greatly by water action. The gravel and sandy material were deposited as overwash plains by streams issuing from beneath the ice sheet. The silty covering may have been deposited later in the quiet waters of glacial lakes, or it may have been laid down by the wind. The gravelly and sandy material is stratified, but no stratification was observed in the silty covering. The gravel in the subsoil is mostly limestone, and the subsoil is never in an acid condition. The surface soil, however, is slightly acid in places.

Native vegetation.—The original timber consisted chiefly of oak and hickory, and the trees were large and thrifty. Practically all of the timber has been removed, and most of the type has been put under cultivation.

*Present agricultural development.**—This is considered a good general farming soil and all the ordinary farm crops of the region are grown upon it. Corn yields from 40 to 50 bushels, oats 25 to 40 bushels, barley 20 to 30 bushels, wheat 20 to 30 bushels, hay from 1½ to 2 tons per acre. The usual rotation consists of corn, barley or wheat, oats and grass. Manure at the rate of 10 to 12 loads per acre is usually applied to sod land before plowing for corn. Dairying is the most common type of farming, and the industry is fairly well developed.

Land of this character sells for $80 to $125 per acre.

SUPERIOR CLAY LOAM.

Description.—The surface soil of this type to an average depth of 8 inches consists of a brown to reddish-brown compact clay loam, which contains a high percentage of silt and frequently approaches a silty clay loam in texture. The subsoil is a heavy, plastic, red clay which extends to a depth undetermined, but which is known to be considerably more than 3 feet. When wet the material becomes very sticky and on drying it checks and cracks into small cubes. Small limestone fragments occur in both soil and subsoil, and small

* For chemical composition and improvement of this type see page 30.

VIEW OF SUPERIOR CLAY LOAM WEST OF FOND DU LAC, SHOWING CHARACTERISTIC LEVEL SURFACE, AND WELL IMPROVED FARMS.

This is a very heavy soil, and is adapted to general farming and dairying. It is excellent grass land, but is deficient in drainage. The view is also typical of Poygan clay.

rounded gravel and a very few stones are sometimes found upon the surface. The stones are so scattering that the type may be considered stone free.

The material mapped as typical Superior clay loam is remarkably uniform in texture, structure, color, and topographic position. The only variation of importance has been called the rolling phase. This has been indicated separately on the soil map, and is described in detail following the description of the typical soil.

Extent and distribution.—The Superior clay loam, is confined to the lowland adjacent to Lake Winnebago and the largest areas occur immediately west of the lake and extending for a few miles to the south and west of Fond du Lac. It is closely associated with the Poygan clay, but occupies a slightly higher elevation, though the difference is often not more than a few feet.

Topography and drainage.—In topography the surface is level or only very slightly undulating and the natural surface and underdrainage is poor. This is the chief point of difference between the type and the rolling phase, where the surface is always sufficiently uneven to insure adequate surface drainage. Open ditches have been constructed but only a few tiles have been used.

Origin.—The material from which the Superior clay loam has been derived is of lacustrine or lake-laid origin, but since its first deposition it has been influenced to a limited extent by ice action. The presence of a few stones and gravel indicates that the ice sheet passed over this type, but the level topography indicates that the surface features were not altered to any marked extent by ice movements. A characteristic feature of the Superior clay loam is that it is calcareous. While this is true of the bulk of the material, the surface soil has frequently been leached to such an extent that a slightly acid condition has developed in a few instances.

Native vegetation.—The original timber growth consisted of oak, ash, elm, ironwood, maple and hickory. Practically all of the timber has been removed, and most of the land has been put under cultivation.

*Present agricultural development**.—All of the type is in farms, though portions of it are too wet during most of the year for the growing of cultivated crops, and such places are kept in grass for hay and pasture. Where adequate surface drainage is provided the soil is well suited to general farming and dairying, which combination forms the chief type of agriculture practiced on the Superior clay loam. All of the crops common to the region are successfully grown. The type is well adapted to grasses and small grains, but not so well adapted to corn as the Carrington silt loam although very fair crops of corn are obtained. The heavy character of the soil and the level surface makes the drainage deficient so that the ground is inclined to be cold and backward in the spring, especially when the rainfall is excessive. This frequently delays planting and cultivating to such an extent that some crops do not fully mature, or the yields secured are below the average because of the unfavorable conditions. Average yields on this type are corn 35 to 45 bushels, oats, 40 to 45 bushels, and hay 1½ to 2½ tons per acre. Wheat was at one time an important crop, but little of this grain is grown at present. Some barely is grown but the acreage does not seem to be increasing. Yields range from 25 to 40 bushels per acre. Where well drained alfalfa can be grown successfully, and a few small fields were seen. Yields average about 3 tons per acre. Three cuttings are usually secured.

The Superior clay loam is one of the most difficult soils in the area to cultivate. If plowed when moisture conditions are the most favorable but little difficulty is experienced in securing a good seed bed, but if the soil is too wet it sometimes puddled and such places will remain to poor physical condition for several years. Clods and large lumps which form are difficult to pulverize and considerable labor and time is required in reducing such fields to good tilth. Fall plowing is practiced quite largely, and where this is done the fields can be worked earlier in the spring, and a good seed bed can usually be more readily secured than when plowed in the spring.

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* For chemical composition and improvement of this soil see page 30.

The rotation of crops most commonly followed on Superior clay loam consists of corn, followed by small grain for one or two years, with clover and timothy seeded with the last grain crop, and hay cut for two years. Sometimes a field may be pastured a year before being again plowed for corn. Stable manure is the only fertilizer used and this is most often applied to sod to be plowed for corn.

SUPERIOR CLAY LOAM, ROLLING PHASE.

Description.—The surface soil of this phase, to an average depth of 8 inches, consists of a brown to reddish-brown clay loam, which contains a considerable amount of silt. The silt content, however, is not sufficient to make the type a silty clay loam. The surface material is usually quite compact. The subsoil consists of a heavy, plastic light-red clay, which extends to a depth which is undetermined, but which is known to be more than 3 feet. When wet, the subsoil is sticky and when dry it checks and cracks into small cubes. Limestone fragments are found in both soil and subsoil, but are more numerous in the subsoil. They occur more extensively in the type east of Lake Winnebago than elsewhere.

A variation was seen in a few small areas, where the surface soil consists of from 4 to 8 inches of a yellowish-gray silt loam, very smooth and free from all coarse particles, resting upon the typical red-clay subsoil. In the virgin soil of these areas the surface is very silty, having the smooth feel characteristic of a silt loam. When this is plowed, however, some of the underlying clay becomes mixed with the surface soil, which tends to make the cultivated fields heavier at the surface than the virgin areas. In a few places the silty covering was found to extend to a depth of 10 to 12 inches.

Extent and distribution.—The rolling phase of the Superior clay loam is confined to the central and northern portions of the county to the east, west, and south of Lake Winnebago and its extreme limits are, in a general way, nearly parallel with the shore of the lake. It covers an area of approximately 25,000 acres or 3 times as much as the area of typical Superior clay loam. Included with the typical soil this comprises one of the leading types of soil in Fond du Lac County.

Topography and drainage.—The topography of that part of the phase occurring south and west of Lake Winnebago is that of a low ridge lying from 10 to 40 feet above the adjacent lowlands, the top having an undulating surface and the side slopes being rather gentle. The latter, however, are steep enough in places to be affected by erosion, so that the lighter colored surface material is eroded, exposing the underlying heavier, redder clay. This is the case also in places on the top of ridges. East of Lake Winnebago the topography of the type is rougher than west of it. It lies along the frontal slope of the escarpment formed by the Niagara limestone, the rolling phase, occurring only where the rock is covered by the coating of red clay. In the northern part of the county the escarpment is much less steep than farther south, so that the topography is smoother.

The surface drainage is generally adequate, though the material is compact and water moves through the subsoil slowly. Even where the surface is sufficiently rolling to drain all the surface water, tile drains would in many places improve the soil. Where the surface of the material is level so as to be naturally poorly drained and of a different agricultural value, such material has been classed as the typical soil.

Origin.—In origin, the material forming the rolling phase of the Superior clay loam is very similar to that of the typical soil, having been first deposited as lake-laid or lacustrine material, and later worked over to a greater or less extent by the action of glacial ice. The glacial action was more pronounced on the phase than on the typical soil, as is indicated by the more uneven topography, and the presence in the material of more gravel and stones. A large proportion of the coarse material, gravel and stones consists of limestone. As with the typical soil, this phase as a whole is calcareous, although there are places of small extent where the surface soil has been leached to such an extent that a slightly acid condition has developed.

Native vegetation.—The original timber growth was practically the same as on the typical soil and consisted of oak, ash, elm, ironwood, maple and hickory, practically all of the timber has been removed and the land placed under cultivation.

VIEW OF SUPERIOR CLAY LOAM, ROLLING PHASE, SOUTHEAST OF PIPE VILLAGE, SHOWING TYPICAL UNDULATING TO GENTLY ROLLING TOPOGRAPHY.

This soil is all highly improved, and devoted to general farming and dairying. The soil is the same as Superior clay loam, but the natural drainage conditions are better.

Present agricultural development.—The rolling phase is not as extensive as the Carrington silt loam or the Miami silt loam, but most of it is as highly developed agriculturally. As is the case with the typical soil, the rolling phase is well adapted to general farming and dairying. Grasses and small grains do very well, and alfalfa is coming to be one of the important crops, especially in the region east of Lake Winnebago.

Yields will average somewhat higher than on the typical soil, especially during wet years. During dry seasons yields are usually about the same. Corn yields from 35 to 50 bushels, oats, from 40 to 50 bushels, and barley from 30 to 50 bushels per acre. Wheat was once an important crop but is grown to only a very limited extent at present. Timothy and clover mixed yield from 1½ to 2½ tons per acre and alfalfa about 3 tons per acre. Three cuttings of alfalfa are usually secured, though four have been made in one season and yields as high as 6 tons per acre have been reported in a number of instances.

Fall plowing is quite generally practiced and it is almost a necessity if good tilth is to be obtained with the minimum amount of labor. The type is apt to be wet in the spring and if plowed in this condition is cloddy, making subsequent cultural operations difficult. When the soil becomes puddled, as sometimes happens, it usually takes several years to get the land back into first-class tilth. The heavy rollers sometimes used to break up the lumps frequently pack the soil too much, and a crusher of plank or some such implement is found to be more effective. When the type is plowed in the fall and the spring cultivation not taken up until the moisture conditions are favorable, a good seed bed can usually be secured without much trouble, although this type is probably more difficult to handle than any of the other soils of the county.

A crop rotation in common use consists of corn, oats, barley or wheat, and hay. Hay is cut for one or two years, after which the field may be pastured for one year. Manure is usually applied to sod land to be plowed for corn. No commercial fertilizers are used.

CHEMICAL COMPOSITION AND IMPROVEMENT OF MIAMI SILT LOAM, FOX SILT LOAM, AND SUPERIOR CLAY LOAM.

In chemical composition these three types of soil are quite similar. They all contain approximately 1200 pounds of phosphorus in the surface 8 inches per acre. The relatively large amount of iron in the Superior clay loam is liable to render the phosphorus somewhat less available than in the other types containing less iron, and attention should be given each case of low yield to determine by direct experiment whether an addition of this element in fertilizer would increase the yield.

The total amount of potassium is large in all of these types, varying from approximately 44,000 pounds in the Miami silt loam and Fox silt loam to 55,000 pounds in the surface 8 inches of an acre in the Superior clay loam. The problem of the potassium supply for crops on these soils is chiefly that of having sufficient organic matter to produce the necessary chemical changes in the inert potassium compounds of the soil to render them available to plants. The total amount of organic matter in these three types is approximately 3 per cent, or 60,000 pounds per acre. This is relatively small and should be increased by every practical method. The total nitrogen content is also relatively small and should be increased by the growth of legumes in all rotations.

The amount of lime or lime carbonate contained in these soils is extremely variable. As a rule, fields which have been cropped for a number of years have lost nearly or quite all the lime originally contained in the surface soil, and have in many cases become acid. The subsoil, however, often still contains very large amounts of this material, sometimes running as high as 20 per cent, but for the insurance of good growths of plants requiring lime, especially alfalfa, this will have to be supplied in all cases where the surface shows a distinct acid reaction, as indicated by the use of the litmus test or the Truog test* for soil acidity.

* The "Truog Test" for determining soil acidity is a new method which has just been perfected by E. Truog of the Soils Department of the University of Wisconsin, by which the relative degree of acidity can be ac-

In the improvement of this group of soils the factor which may well be given first consideration is a means of increasing the amount of organic matter and the supply of nitrogen. As the supply of stable manure is usually inadequate, it should be supplemented by green manuring crops of which the legumes are the best. Plowing under a second crop of clover once during each rotation will greatly assist in increasing the productivity of the soil. This will not only increase the supply of nitrogen in the soil but it will also improve the physical structure, which is highly desirable especially in the case of the Superior clay loam. The presence of a large amount of organic matter will also assist in making available for the plant a larger amount of potassium, which is present in sufficient quantities in these soils, but which is often in such a form as to be of little use to the plant.

As indicated by various field experiments the heaviest member of this group, the Superior clay loam,* responds very well to the application of phosphate fertilizers supplementing the stable manure.

By using ground rock phosphate to supplement manure the yield of clover hay was increased 43 per cent over plots which received only stable manure. Likewise the yield of potatoes was increased 47 per cent by the use of ground rock phosphate. The rock phosphate may be applied at the rate of about 600 pounds per acre, once during each crop rotation. As the phosphorus in this form is only slowly available there will be but little, if any, loss if larger applications are made. The results obtained leave no doubt that the use of rock phosphate supplementing manure on the Superior clay loam is beneficial, and therefore wherever this type of soil is found the above treatment may be safely and successfully followed. This same treatment will doubtless give profitable results on Miami silt loam and Fox silt loam, but fewer tests have been made than on the heavier soil. It would be well therefore to make pre-

curately determined in the field or laboratory in a few minutes time. For a detailed description of this method write the Soils Department, College of Agriculture, Madison, Wis.

* For more information on heavy clay soils consult Bulletin 202, Wisconsin Experiment Station on "How to Improve Our Heavy Clay Soils".

liminary tests on small plots before applying this method to entire fields.

Wherever an acid condition is found to exist on any of these soils this should be corrected by the application of from 1200 to 2000 pounds of ground limestone per acre, the amount depending upon the degree of acidity. The limestone may be applied at any convenient time as it is slowly soluble and will remain in the soil for a number of years.

The question of drainage* is a very important one, especially on the typical Superior clay loam where the surface is level and where the water moves off slowly. Practically all of this soil would be greatly benefited by tile drains, and while their use is not essential to the production of profitable yields, it is known that when properly placed they will pay for themselves in the course of a few years. As land values in this section are high it is important that every portion of the farm should produce maximum yields, but such yields cannot be secured unless the soil is well drained. Because of wet conditions which often prevail in the spring, planting is frequently delayed and it is not uncommon to see numerous low spots in a field which produce nothing. There are a number of places on the rolling phase of the Superior clay loam, and on the Miami silt loam which would also be benefited by tile drains. Open ditches may frequently be used to advantage to supplement the tile drains, but they should not be depended upon entirely. Where the surface is level the land may be plowed in narrow strips leaving dead furrows from 2 to 4 rods apart. When these are kept clean the surface water will flow through them into open ditches along the side of the field. This system has given very good results when used by itself, but the drainage of the land is much more complete, and better results are obtained when such surface drains are used to supplement a system of tile drains.

Another factor which is very important in the improving of heavy soils is cultivation. The Superior clay loam is more difficult to handle than the silt loam types in this group, and great care should be exercised in all cultural operations. All

* See Wisconsin Bulletin 329—The Right Drain for the Right Place.

working of heavy clay soils should be done only when dry enough not to puddle. Plowing when too wet will have a bad effect for 3 or 4 years. Before a crop is planted the soil should be thoroughly pulverized and the seed bed in a loose, mellow condition. All after cultivation of intertilled crops should be sufficiently frequent to maintain a good surface mulch, to conserve the moisture and to permit a free circulation of air through the soil.

The silt loam types may be worked under a considerably wider range of moisture conditions than the clay loam, and fields can be kept in good physical condition with a smaller amount of labor, but the necessity of thorough cultivation on all of these soils should not be overlooked.

On the Superior clay loam a 4 or 5 year rotation seems to give the best results. The first crop may be small grain, such as rye, oats, barley or wheat, seeded down to clover, with a little timothy mixed in it. The second year the clover will be grown, the first cutting for hay and the second left to grow for seed. The third year, crops of mixed clover and timothy will be harvested. Manure may be spread on the sod either before plowing in the fall or on the plowed land in the winter. The fourth year the land should be put into cultivated crops. In this scheme of crop rotation, one-fourth of the land is in grain, one-fourth in clover, one-fourth in mixed clover and timothy, and one-fourth in cultivated crops. This same system may well be followed on the silt loam types, but minor modifications may be necessary to fit the conditions of individual farms.

While the dairy industry is highly developed on these soils it could be profitably extended to still greater proportions. Alfalfa has proven to be a successful crop, and it should be grown on every dairy farm. The soils of this group, and especially the Superior clay loam, are well adapted to the growing of peas, and the acreage of this crop could also be profitably extended. Sugar beets, mangels, rutabagas and turnips also do well and may often be added to the list of profitable crops. When green manuring is to be practiced the second crop of clover may be plowed under and followed by corn, and

two small grain crops grown in the rotation in place of one.

Since the soils of this group cover nearly 50 per cent of Fond du Lac County, and include much of the finest agricultural land in this region, it will be realized that the question of keeping up, or of increasing, their productivity is one of great importance, and one which should receive the careful consideration and study of every farmer located on these soils.

CHAPTER III.

SOILS OF THE PRAIRIE REGIONS.

CARRINGTON SILT LOAM.

Description.—The surface soil of Carrington silt loam consists of a black to a very dark brown, smooth-textured silt loam, about 12 inches deep, containing a comparatively large quantity of organic matter. The subsoil consists of a dark-brown silt loam, becoming lighter in color with depth and grading into a yellowish brown or sometimes yellow below 18 inches. The clay content gradually increases until at 20 to 30 inches it becomes a heavy silty clay loam. At a depth of 3 feet or more small amounts of fine sand are sometimes found with the heavy material.

A well marked variation in the type is found associated with areas of Clyde clay loam. This represents differences in the weathering of the surface and subsoil. Where the ground-water level is lowered, so that the bluish-drab subsoil of Clyde clay loam is exposed to the oxidation and weathering of the atmosphere, the color gradually changes to a yellow and the soil approaches more nearly a heavy phase of Carrington silt loam. In places the surface of Carrington silt loam may contain a noticeable quantity of fine and very fine sand, although this is the exception, as the type as a whole is very uniform. The depth of soil to bed rock is not as great as in Miami silt loam, varying from 2 to 10 feet, with occasional outcrops. The deep subsoil contains some gritty material, gravel and a few stones.

Extent and distribution.—Carrington silt loam is one of the most important soils in the county. It is confined to the western part of the survey and the most extensive developments are found in the country between Ripon and Waupun. Asso-

ciated with the type are areas of Miami silt loam and some Carrington gravelly loam.

Topography and drainage.—The topography is level to undulating and in places gently rolling. The type is more nearly level than Miami silt loam in the western part of the area. There are no steep slopes and erosion is not a problem of importance. Rarely is any Peat or Clyde clay loam found associated with Carrington silt loam where the surface is level. A few marshes occur over the rolling areas. Natural drainage is fairly good over most of the type, although in a number of sections, especially where the surface is nearly level, the under drainage could be greatly improved by tiling. Areas of level surface overlying bed rock at shallow depths are often droughty during dry spells and slow to absorb soil moisture after heavy rains. Unless the subsoil is several feet deep over bed rock, which is in places broken or fissured, there is often a lack of moisture when the rainfall is not well distributed. Tile drainage has not been practiced to any extent in this type.

Origin.—In origin Carrington silt loam consists of a loess-like material deposited over the till of the ground moraine. The lower part of the soil section has the true character, lacking stratification and containing some coarse material, but the surface is very silty, free from coarse particles and similar to loess in structure. The dark color of the soil is due to the accumulation of vegetable matter. While the glacial material from which most of the type is derived contains fragments of limestone, rests upon limestone, and is probably largely composed of this rock ground to a powder, the surface contains but little carbonate of lime, and an acid condition prevails over much of the type.

Native vegetation.—Carrington silt loam is a typical prairie soil and the native growth consisted of prairie grasses. Along the margin of the type, along some of the stream courses, and over some knolls a few forest trees were found when the country was first settled. These consisted chiefly of elm, maple, and oak. Practically all of the trees now growing on the type were planted.

VIEW OF CARRINGTON SILT LOAM SOUTH OF RIPON, SHOWING UNDULATING TO GENTLY ROLLING TOPOGRAPHY, AND A TYPICAL FARMSTEAD.

This type consists of black prairie land. It is an excellent corn soil and is also well adapted to general farming and dairying.

Present agricultural development.—Carrington silt loam is one of the leading types in the county, and a larger proportion of it is under cultivation than of any of the other soils. The areas are highly improved and appearances indicate a thrifty condition of agriculture. Dairying in conjunction with general farming is the prevailing type of farming. Hogs are also raised quite extensively.

The crops consist of corn, oats, barley, hay, some wheat, and a little alfalfa. For small grains the type hardly equals the Miami silt loam in the quality of the grain produced, although the yields are about the same. Carrington silt loam is better adapted to corn than the Miami silt loam and it is probably the best corn soil in the area at the present time. Corn yields from 35 to 80 bushels per acre, oats from 35 to 70 bushels, barley 25 to 45 bushels, wheat 15 to 30 bushels, and hay from 1 ton to 2½ tons per acre. Alfalfa is grown to a limited extent and yields from 2 to 4 tons per acre. Considerable variations occur in the yields, owing largely to differences in farming methods.

The cultivation of the type is easy if plowing is done under proper moisture conditions. Many farmers plow in the fall, although the type can be worked earlier in the spring than the Superior and Poygan soils. A good mulch can be readily obtained in soils of such silty texture. The subsoil is retentive of moisture, and where the underlying rock is not too close to the surface the type resists drought fairly well. As the dairy industry is well developed, there is a good supply of manure, which is applied at the rate of 10 to 15 loads per acre every four or five years. The application of ground limestone to correct acidity is being tried by a few farmers, but the practice has not as yet become general.

The rotation most commonly followed consists of corn, barley, oats, and hay. Wheat was at one time the leading crop, but is grown now only to a limited extent and in some communities is not sown at all.

Among the special crops grown sugar beets may be mentioned. The type is well adapted to their production, and yields of 10 to 15 tons per acre are obtained. Tests as high as 17 per cent have been obtained, but this is above the average.

Cabbage is grown extensively in the vicinity of Waupun, where it is made into sauerkraut. Peas for canning are also grown here. Around Ripon cucumbers are grown extensively for the pickle factory located at that place. Raspberries, blackberries, and strawberries do very well, from $200 to $300 per acre being sometimes realized from such crops, although not grown on a large commercial scale. Potatoes are grown mainly for home use, though many farmers have some to sell each year.

In the methods of cultivation followed, crop rotation practiced, and in the general conditions existing Carrington silt loam is comparable with the Miami silt loam.

Farms on the Carrington silt loam sell for $75 to $150 an acre, depending on the location and improvements.

CHEMICAL COMPOSITION AND IMPROVEMENT OF CARRINGTON SILT LOAM.

The mineral basis of this type of soil is similar to that of the Miami slt loam and in total potassium and lime it shows the same characteristics. Its total content of phosphorus is somewhat larger, averaging about 1600 pound to the acre 8 inches. The larger amount of organic matter characterizing this type is probably the cause of the accumulation of somewhat larger amounts of phosphorus than contained in other types of soil having less humus. But it must be remembered that soils of this character which had originally a high degree of fertility on account of this large amount of organic matter, a considerable portion of which would decompose readily after the land was broken, lose this marked fertility as the result of a number of years of cropping, even though they still have a relatively large amount of humus. The humus remaining is of an inert resistant character which does not decompose readily and therefore does not serve the purpose of fresh vegetable matter. The phosphorus, although large in total amounts, is very commonly less available than in the lighter colored soils so that some form of fertilizer containing this element is usually needed to enable these soils to produce the best results.

On account of the large amount of organic matter which has decomposed in this soil it is almost universally acid, at least

in the surface soil, and frequently this acidity is very considerable so that the use of relatively heavy applications of lime will be needed to fit such land for the growth of alfalfa and often even of medium red clover. Applications of from 2000 to 4000 pounds of ground limestone per acre will usually be sufficient to correct the acidity, but in some cases a larger amount than this may be necessary. There is an abundant supply of limestone close at hand throughout the regions covered by this soil, and by coöperation among the farmers it may be crushed at a very small cost.

The use of ground rock phosphate, as a source of phosphorus, has been found to give good results on Carrington silt loam, and a few farmers are beginning to use it in Fond du Lac County. Its use should be extended to all areas of this soil, since by supplementing the stable manure with this commercial fertilizer the productivity of the soil can be materially increased. About 600 pounds per acre will usually be found sufficient for the first application. Smaller applications can be made once during each succeeding rotation. As the phosphorus in this form is only slowly soluble it will remain in the soil for a number of years, and but little will be carried away by the drainage waters.

As indicated by the analyses made of this soil, and referred to above, there is a large amount of organic matter present but the humus remaining is of an inert resistant character and as in this form it decomposes slowly it is of little value to growing crops. The organic matter supply of this type should therefore be supplemented by fresh vegetable matter in the form of green manuring crops, of which the legumes are best. As the fresh vegetable matter decomposes it will also assist in making available larger amounts of potassium. It will be found that by supplementing the stable manure with green manuring crops and rock phosphate that the fertility of Carrington silt loam will be greatly increased, and the margin of profit in farming this soil will be considerable larger.

Another factor which may well be considered in the improving of this soil type is the question of tile drains. There are a number of places where the surface is nearly level or undulating, and where the subsoil is sufficiently heavy so that the in-

ternal movement of water is sluggish. This frequently delays planting and cultivation in the spring, and keeps the ground cold so that plant growth is checked and crop yields reduced as a result of this condition. Tile drains are not at all common on this soil, but their use should be encouraged, since they will greatly assist in improving the physical condition of the soil, permit low places to warm up and dry out quickly in the spring, and permit the uniform development of a crop over all parts of fields.

The following rotation is one which gives good results on this soil, and may well be followed as given here, or it may be used as a basis for working out other rotations to fit special needs. Small grains consisting of oats, barley, or wheat may be grown the first year and seeded with a mixture of clover and timothy. The second year the first crop of clover may be cut for hay, and the second left for seed. The third year a crop of mixed clover and timothy can be harvested. The field may then be pastured a year, or manure may be applied to the sod either before the land is plowed in the fall or on the plowed land during the winter. The following year corn may be grown. When it is desired to plow under a crop of clover this may be done by following a three year rotation. In this case only clover should be seeded with the grain. The first crop of clover should be cut for hay, and the second plowed under. The following year corn or some other cultivated crop may be grown. Two grain crops may be used in such a rotation, extending it over 4 years.

As dairying is an important branch of farming on this soil alfalfa should be grown to a greater extent. When the soil is limed and inoculated, and in a good state of fertility this crop does very well. Special crops such as peas and cabbage as are now being grown in certain localities could well be grown on a larger scale. The Carrington silt loam may well be considered one of the best agricultural soils in the State, and it is doubtless well adapted to a wider range of crops than are now being grown. It is therefore desirable and important that the questions of crop adaptation and methods of improvement should be given careful consideration by all who are interested in this type of soil.

CHAPTER IV.

GROUP OF GRAVELLY LOAM SOILS.

MIAMI GRAVELLY LOAM.

Description.—Miami gravelly loam consists of a light-brown to yellowish-brown silt loam extending to an average depth of 8 inches, and underlain by a brown to yellowish-brown silty clay loam or slightly reddish brown, stiff sandy gravelly clay. This in turn is underlain by a heterogeneous mixture of sand, gravel, clay, and bowlders, varying in thickness from 2 or 3 feet to over 25 feet in places. Gravel and bowlders in varying quantities are frequently found upon the surface and mixed with the soil.

Miami gravelly loam in Fond du Lac County may be divided into the typical soil and two phases which are distinct, although not of sufficient importance in themselves to be classified separately. The first is found on hills more or less regular in shape and varying in height from 25 to 150 feet. The soil on the steeper slopes is frequently thin, the gravel often coming to within 12 inches of the surface. The silty covering has in some places been removed by erosion. On the tops of these hills there is a greater depth of soil, and in places it is sufficiently deep to be classed as Miami silt loam. Where gravel was not found nearer the surface than 22 to 28 inches and the area was large enough to be mapped the material was classed with the Miami silt loam.

One phase consists of areas where the topography is bumpy and ridgy. In such locations the gravel at times approaches within a few inches of the surface, while in the intervening depressions the surface soil extends to a considerable depth. Where these knolls are found close together the whole region has been mapped as gravelly loam. Where the gravel ridge in itself was of sufficient extent to map it has been classed as Rodman gravel, while the low-lying areas where the soil was

found to be deep were mapped as Miami silt loam. These two conditions are found most largely in the eastern and south eastern parts of the county.

The other phase is confined to the western part of the survey. The type occurs here on small knolls or hills having a rock core. The underlying limestone approaches the surface and outcrops frequently. The solid portion of the rock is often covered with a broken mass of irregular rock fragments. This material is usually covered with 10 to 24 inches of good soil, though the soil section is itself sometimes filled with broken rock and the surface strewn with fragments varying in size from one-half inch to several inches in diameter. Angular bowlders are also seen in many places on the type. Many of these knolls are very small, and where standing alone can not be indicated on the map; where several appear close together or where individuals are of sufficient size they are shown.

Extent and distribution.—Miami gravelly loam is most extensively found in the eastern part of the county where the typical soil chiefly occurs, but this type is found to a limited extent in all parts of the survey where Miami silt loam has been mapped. This gravelly loam covers 9.6 percent of the county.

Topography and drainage.—The topography varies considerably. In some places it is bumpy and broken, although over most of the area it is rolling. On the large hills in the eastern part of the county the slopes are sometimes steep and broken. In these places the prevention of erosion is a serious problem, and in many places where the land has been left uncovered for a season large gullies have been formed. It is only with difficulty that such erosion can be checked when once started. Throughout all the type the natural drainage is good and in some places it is excessive, causing the soil to be droughty in years of low rainfall.

Origin.—Miami gravelly loam has been derived from the glacial till which covers most of the region. It occurs in the form of drumlins, kames, eskers, and moraines. In the western part of the county the underlying rock has contributed to the type by supplying the broken and weathered rock fragments found in the till. The gravel in the moraine material is 90 to

95 per cent limestone. Much of the gravel material has weathered to form the fine earth soil.

Native vegetation.—The original forest growth consisted chiefly of maple, oak, and some hickory. The growth was heavier than that found on Miami silt loam in the eastern part of the county.

*Present agricultural development.**—Where there is a covering of from 16 to 24 inches of soil over the underlying gravel, and the topography is not too steep, good crops are grown on this type during seasons of average rainfall, but where the broken limestone comes within a foot of the surface and small outcrops occur, or where the covering of soil has been eroded away, the yields are low, as the type is droughty and difficult to handle. In such places it is of value for grazing rather than for cultivated crops. The soil along the lower slopes and in the depressions is as productive as Miami silt loam.

Because of the variable character of the type it would be difficult to give yields which might serve as a fair basis for estimating the productivity of this type. In general it may be said that the yields are lower than those obtained on Miami silt loam, although on the better portions of the type the yields frequently equal the average of the silt loam. The same general farm crops are grown as on the silt loam. About the same rotations are followed, and fertilization is confined to applications of barnyard manure.

The value of the best land of this type, where favorably located, is about $75 an acre. Where the soil covering is thin and the rock outcrops frequent, or where the gravel comes close to the surface, the value is considerably less, probably not over $15 an acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil:

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* For chemical composition and improvement of this type see page 46.

Mechanical analyses of Miami gravelly loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil.....	1.3	4.4	7.0	18.2	13.3	37.3	18.4
Subsoil.....	1.9	5.5	6.5	22.6	22.2	26.7	14.2

SUPERIOR GRAVELLY LOAM.

Description.—Superior gravelly loam consists of a brown or reddish-brown heavy sandy loam to clay averaging 19 inches in depth and containing small amounts of medium to coarse gravel. This is underlain by a gravel bed varying in thickness from 18 inches to several feet, which in turn rests upon the red Superior clay material. The gravel bed contains stratified sand and gravel, the latter ranging in size from small pebbles to cobbles of different sizes.

Where associated with the Poygan clay the soil is much darker in color, but such areas, because of their small extent, could not be mapped separately.

Extent and distribution.—This is one of the minor types of the country and occupies a total area of only 2 square miles. It is found in long, narrow, broken ridges from 10 to 30 acres in extent, running parallel with, and from one-half to 4 miles back from the shore of Lake Winnebago.

Topography and drainage.—As indicated above, the type occurs as low ridges, which have an elevation of from 1 to 10 feet above the level of the surrounding country. Because of the shallow soil covering, and the sandy gravelly nature of the subsoil, the natural drainage is good and sometimes excessive.

Origin.—The soil is of glacial-lacustrine origin. The gravel is beach gravel and represents the shore line of Green Bay and Lake Winnebago when the waters stood at higher levels than at present. A very definite shore line has been traced through Fond du Lac and adjoining counties at the 800-foot elevation. Most of the gravel in the subsoil is limestone, and the type as a whole is quite calcareous.

Native vegetation.—The original timber growth was chiefly of oak, with a few other species of hardwood. About three-fourths of the type is still in forest, though the growth is somewhat scrubby.

*Present agricultural development.**—About 25 per cent of the type is still utilized for cultivated crops. Fair yields of corn, oats, barley, and wheat are obtained, but the type is droughty and crops suffer unless the rainfall is well distributed throughout the growing season. Crops do best where the gravelly loam occurs with Poygan clay and where the soil has a larger content of organic matter present. Some alfalfa has been grown with success.

CARRINGTON GRAVELLY LOAM.

Description.—Carrington gravelly loam consists of a dark-brown or nearly black silt loam, extending to a depth of 4 to 8 inches, where it grades into a gravelly loam or gravelly clay loam containing bowlders and limestone fragments. In places a bed of gravel or sand is found at a depth of 2 feet. The underlying rock outcrops in places, though the till may have a depth of nearly 20 feet. Where the bed rock is near the surface angular limestone fragments are more numerous on the surface. Where the till is deeper the stones on the surface are more rounded and more often of crystalline rock.

Extent and distribution.—This type is confined to the western part of the county where it is always associated with the Carrington silt loam. The total area is small, there being a little less than 2000 acres in the county.

Topography and drainage.—Carrington gravelly loam occurs on the top of long narrow ridges, kames, and steep slopes. Frequently small knolls from 5 to 10 rods in diameter, and from 5 to 20 feet high were found scattered through the Carrington silt loam, but because of their limited areas such knolls could not be indicated. Because of the uneven surface, and the character of the material forming of type, the natural drainage is excessive, and the soil is droughty.

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* For chemical composition and improvement of this soil see page 46.

Origin.—This soil is of glacial origin. The rock cores found in many of the hills and knolls represent remnants of preglacial erosion. While most of the gravel and stones in this soil are of limestone, and while much of the fine earth is doubtless of limestone origin the surface soil is frequently acid.

Native vegetation.—The type constitutes a part of the prairie section, and as a whole was not forested, although on some of the knolls there was a scattering tree growth consisting chiefly of oak.

Present agricultural development.—Where rock lies close to the surface the type is of little value for cultivated crops, and small areas of this sort in many places break the fields and cause inconvenience in plowing. Where there is a good covering of soil and the rock fragments are not too numerous fair crops are grown. The yields on such places in some seasons equal those from Carrington silt loam, though taking the type as a whole the yields are considerably lower. Alfalfa could be grown where the soil is deep, as the drainage is excellent.

CHEMICAL COMPOSITION AND IMPROVEMENT OF MIAMI, SUPERIOR, AND CARRINGTON GRAVELLY LOAMS.

The differences between gravelly soils and those relatively free from stony matter in this section are chiefly due to the fact that most of the gravel is limestone. The total amount of phosphorus is somewhat higher in the gravelly soils than in the silt loam soils, but a considerable portion is probably contained in the relatively coarser grains of the soil and so is not as available as that in soils of finer texture. The total potassium content is approximately the same and its availability depends on the amount of actively decomposing vegetable matter. The lime content is naturally very high, especially in the subsoil where in some cases it is over 35 per cent, or more than one-third of the total weight of the soil. Even the surface soil usually contains a good supply of this substance so that these soils are seldom acid and are well adapted for this reason, as well as on account of good under drainage, to the growth of alfalfa and clover, except, of course, where the gravel is so coarse and comes so near the surface that the crop suffers from drought. The Carrington

gravelly loam on account of its larger amount of organic matter occasionally becomes acid for the reason given in the discussion of the Carrington silt loam. While these soils differ in total amount of organic matter, that contained in the Carrington gravelly loam of older fields has become so resistant that all these types should be considered as lacking in vegetable matter, and so managed as to increase this material as much as possible.

As indicated by the analyses of these soils probably the most important factor which should be considered in their improvement is the addition of a larger amount of organic matter. This can be accomplished by supplementing the available stable manure with green manuring crops, of which the legumes are best. Such additions of organic matter will not only add nitrogen to the soil, but the water holding capacity will be increased, the physical condition improved, and larger amounts of potassium will be made available for plant growth..

Where an acid condition has developed, as may sometimes be the case, ground limestone should be applied at the rate of about 1500 pounds per acre. This may be applied at any convenient time since in this form the carbonate is only slowly soluble and will remain in the soil for a considerable time.

Another factor which should be given consideration in the cultivation of this group of soils is the question of preventing erosion. There is more danger from this source on Miami gravelly loam than on the other types. In a number of places the slopes are sufficiently steep so that special methods of cultivation and cropping should be followed to prevent the soil from washing. Where slopes are forested they should be allowed to remain timbered. Where cleared the steepest slopes should be kept in grass and pastured as much of the time as possible. Plowing should be done with the contour of the hills, and it is not advisable that intertilled crops should be grown on steep slopes. In practically all cases there are enough gentle slopes and depressions between the gravelly hills to afford sufficient land for the growing of corn and other intertilled crops.

As the soils of this group frequently occur in small tracts, and as many fields contain only a small proportion of a gravelly loam soil, it usually follows that the rotation practiced is the one best adapted to the soil making up the largest proportion

of the field. In some cases the same rotation will be adapted to both soils, while in others it will be adapted to only one soil. It is suggested that wherever the slopes are sufficiently gentle to safely permit the growing of intertilled crops that a five year rotation be followed consisting of small grain, clover, clover and timothy, pasture and corn. Where the slopes become to steep for intertilled crops the corn may be omitted, and the time devoted to pasturing or the cutting of hay increased accordingly. These soils are in most cases well adapted to alfalfa, and many of the fields could well be kept permanently in this crop. When the stand becomes poor the field should be reseeded.

CHAPTER V.

GROUP OF DARK-COLORED, POORLY DRAINED SOILS

POYGAN CLAY.

Description.—The surface soil of Pogan clay consist of a dark-brown to black silty clay loam about 10 inches deep, rather sticky and plastic when wet, and inclined to check and crack when dry. The dark color is due to accumulations of organic matter, the content being much larger than in Superior clay loam.

The subsoil consists of a stiff, tenacious red clay extending to a depth of 3 feet or more. The color grades from black to red, with a slightly bluish cast between soil and subsoil. Small lime concretions and particles of limestone are found scattered throughout the subsoil.

The type is fairly uniform, except along streams, where the surface is in some places slightly loamy, and in the northwestern part of Section 12, Lamartine Township, where the soil has a silty texture. The greatest variation occurs in the color of the subsoil. In lowlying, poorly drained areas the subsoil is frequently yellow, bluish, or drab, with occasional iron stains. Red clay is sometimes found beneath the drab material within reach of the auger. This pronounced coloring is due to advanced oxidation, which, in the case of the yellow and blue clays, has been retarded by poor drainage.

Extent and distribution.—The type is found in the vicinity of Lake Winnebago, where it occupies the low-lying sections associated with the Superior clay loam area. A large area extends south and west from the lake into Oakfield Township. The type is confined to an area that was probably an extension of the lake when the waters stood at a higher level.

Topography and drainage.—The surface of this type is low, and the topography is level to very gently undulating. Most

of it occupies a postion slightly lower than the typical Superior clay loam, and practically all of this soil lies below the 800-foot contour line. Because of the low position, level surface, and heavy soil the natural surface and internal drainage is deficient. Open ditches and tile drains are necessary before maximum yields can be secured.

Origin.—The type is of the same origin as Superior clay loam having been deposited in interglacial times, when the waters of Green Bay and Lake Winnebago were more extensive. The material does not seem to have been influenced to as great an extent by glacial action as the Superior type. Owing to a low, poorly drained position, conditions have favored the accumulation of a large quantity of organic matter in the soil. Litmus tests occasionally show traces of acidity.

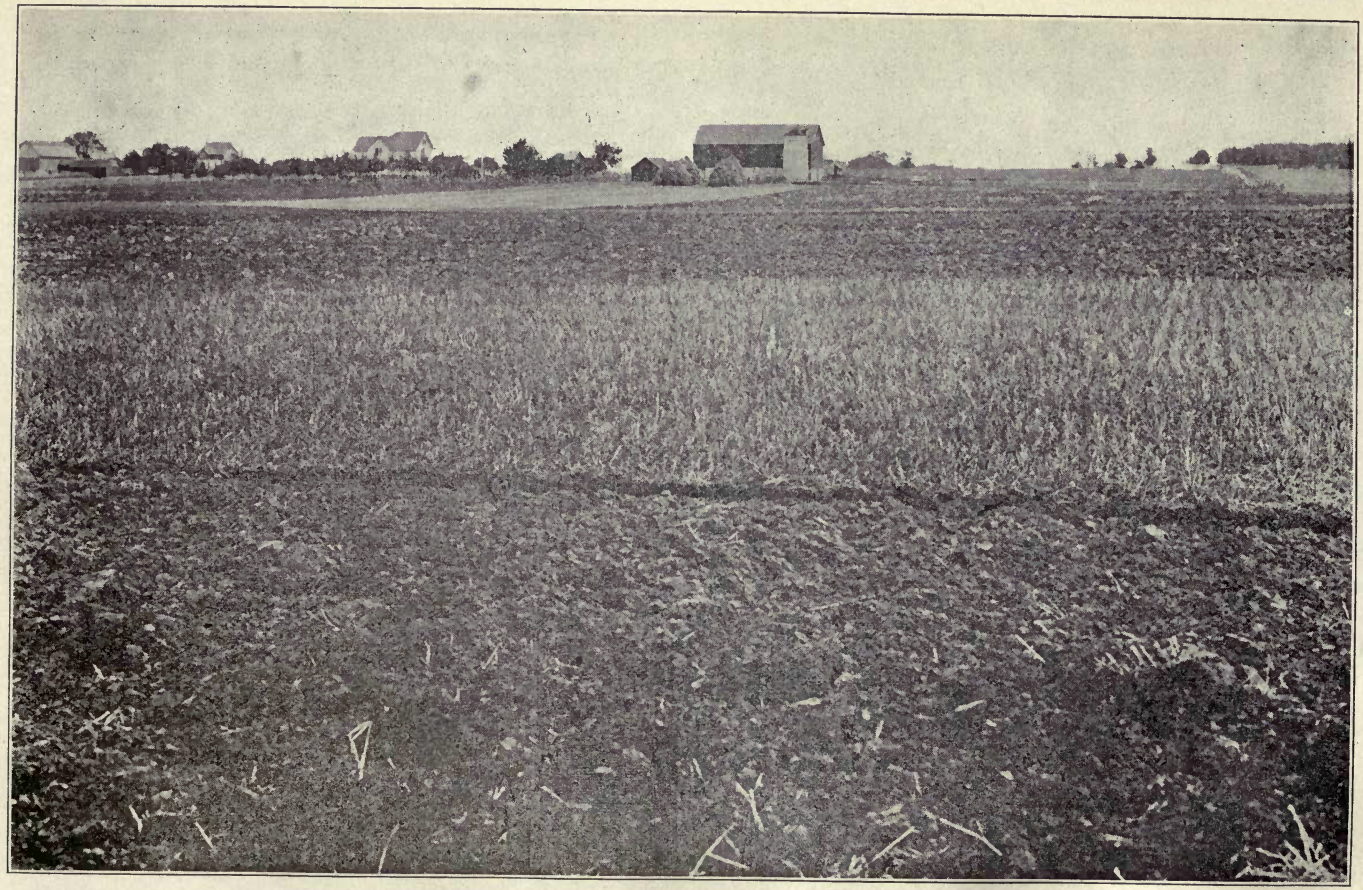
Native vegetation.—As is usual in low, wet lands, grasses form the most important vegetation, with few trees. The original tree growth consisted chiefly of willow and poplar in the wetter places, with elm, some oak, and hickory where the land was better drained. Some areas of the type are spoken of as prairie land.

*Present agricultural development.**—From 60 to 70 per cent of the type is under cultivation to the general farm crops, of which corn is the most important. The type is better adapted to its growth than is Superior clay loam and yields of 40 to 60 bushels per acre are not uncommon. Oats yield from 40 to 50 bushels, barley 25 to 40 bushels, wheat 25 to 30 bushels, and hay from 1½ to 2½ tons to the acre.

Sugar beets are grown as a special crop, yielding from 12 to 15 tons per acre. The lighter phases of the type are better adapted to this crop than the areas of heavy soil. In the vicinity of Fond du Lac some trucking is carried on to supply the city market. Alfalfa is grown to a limited extent. On the best drained areas it does well and yields from 3 to 4 tons per acre.

As is the case with Superior clay loam fall plowing is extensively practiced, for in the spring the land is likely to be wet and not in condition to work until late. When plowed in the

* For chemical composition and improvement of Poygan clay see page 54.



VIEW SHOWING POYGAN CLAY IN THE LEVEL FOREGROUND, GRADING INTO SUPERIOR CLAY LOAM, ROLLING PHASE, NEAR THE FARM BUILDINGS.

The Poygan clay is closely associated with the Superior soils. It is darker in color, contains more organic matter, and occupies a lower position than the Superior soils. It is a good general farming soil but requires drainage.

fall and not cultivated in the spring until the moisture conditions are the most favorable, but little difficulty is experienced in obtaining a good seed bed. If plowed when wet, especially in the spring, the soil clods and is hard to handle.

Dairying has developed into an important industry on this type, and there is consequently a large amount of manure available. The manure is chiefly used on fields which have been standing in pasture, before breaking the land for corn. No commercial fertilizers are used. The crop rotation most commonly followed consists of corn followed by small grain, which may be grown on the same field for 2 or 3 years when the field is seeded to timothy and clover. Sometimes the seeding is omitted and the fields are put back into corn following the small grain. On account of the poor drainage conditions definite crop rotations are not as closely followed on this type as on some of the better drained soils. Clover is grown less on this soil than on many other types.

Drainage is the most important factor to be considered in the management of this type. Fields are frequently plowed in narrow lands, allowing the dead furrow to act as a shallow ditch which conducts the water to other open ditches along the side of the fields. In most cases this system is inadequate, as the heavy clay subsoil makes the internal drainage sluggish. Tile drains should be installed wherever practicable.

Land of this type ranges in value from $40 to $125 an acre, depending upon the drainage conditions, location, and improvements.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of Poygan clay.

Mechanical analyses of Poygan clay.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.0	0.9	1.3	3.0	4.1	46.6	44.0
Subsoil	.4	2.1	1.9	5.2	7.7	37.9	44.4

CLYDE CLAY LOAM.

Description.—The surface soil of Clyde clay loam, to an average depth of 10 inches, consist of a dark-brown or black clay loam, containing considerable silt and having a high content of organic matter. The subsoil consists of a drab or bluish colored, heavy, plastic silty clay loam. Throughout the drab subsoil are found yellow iron segregations. These become more numerous with depth and in places are so thoroughly disseminated as to give the material a yellow color. In the lower subsoil a smaller percentage on fine and very fine sand usually is present.

Included in the type are some areas of lighter texture, as in section 27, Taycheedah Township, where the surface is a dark-brown loam, underlain by a bluish or yellowish plastic clay. The subsoil becomes gritty in the lower depths and sand is often found at 24 to 30 inches. Where the type is associated with areas of Miami sandy loam or other sandy types there is more sand in the soil than typical. In the northwestern part of section 32, Auburn Township, is an area of sandy loam a few rods wide, where the surface is nearly black and where the subsoil grades into a gritty clay loam at 16 inches. The heaviest phase of Clyde clay loam is found to the west and north of Oakfield, where it is associated with, and closely related to, the Poygan clay. Over this area the red clay deposit giving rise to the Superior soils is something found at a depth of 28 to 30 inches, though it is very generally mottled with blue and yellow. This condition usually occurs wherever Clyde soils are associated with the Superior or Poygan soils.

Extent and distribution.—Clyde clay loam occurs in all parts of the county. It occupies depressions and low-lying areas within the other types. It is found quite commonly along stream courses, in places where the accumulation of organic matter has not been sufficient to form Peat or Muck. The largest area lies west and north of Oakfield, in the basin once occupied by an extension of Lake Winnebago.

Topography and drainage.—The topography is level or very slightly undulating. On account of this condition and the heavy character of the soil the natural drainage is very defi-

cient. Before satisfactory crops can be secured thorough drainage systems must be installed.

Origin.—The soil has been formed in old glacial lake basins, ponded valleys, and kettle holes carrying accumulations of organic matter but not sufficient to form Peat or Muck. This type has been modified in places by soil material washed from higher lying areas. Some of the areas occurring along streams may have received a variable amount of alluvial material deposited from flood waters, but for the most part this influence was not considered to be of sufficient importance to constitute a true alluvial soil, and such areas were included with Clyde clay loam, as being of about the same agricultural value. A characteristic feature of the Clyde clay loam is that it is quite calcareous.

Native vegetation.—The native vegetation consists quite generally of grasses and sedges, especially where the land is wet most of the time. On other areas elm, ash, poplar and willow are found.

Present agricultural development.—Only a small percentage of the type has been put under cultivation. The largest tilled areas are found north and east of Oakfield, where the drainage conditions have been improved by digging ditches, and where the land is slightly elevated. Some of the type west of Oakfield has also been improved. Aside from these areas most of the soil is too wet for cultivation in years of normal rainfall. Where the land is properly drained excellent crops are produced, the type being especially well adapted to corn and grasses. Corn yields 50 bushels per acre, and from 70 to 80 bushels are sometimes obtained. Timothy and alsike clover do well. Small grains produce too rank a growth of straw and are apt to lodge. Sugar beets grow luxuriantly and yield from 15 to 18 tons per acre. While the sugar content is relatively low, the yield per acre is usually higher than on the Miami silt loam. Other crops, such as cabbage and onions, while not grown extensively in the county, are profitable crops on similar soils in other places and might well be introduced here. At present the larger part of the type is used for marsh hay and pasture.

Land of this type varies in value from $10 to $100 an acre, depending upon location and drainage conditions. The average price is about $25 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type.

Mechanical analyses of Clyde clay loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent	*Per cent*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*	*Per cent.*
Soil	0.8	1.2	0.6	1.5	9 0	59.8	27.0
Subsoil	.3	.9	.6	1.3	11.6	58.7	26.5

CHEMICAL COMPOSITION AND IMPROVEMENT OF POYGAN CLAY AND CLYDE CLAY LOAM.

These types of soil are characterized by having relatively large amounts of organic matter, accumulated as a result of poor drainage. As is usually the case, accumulation of organic matter increases the total content of phosphorus, but this does not necessarily mean that this element is readily available. Its availability will depend largely on the rate of decomposition of the vegetable matter. It is frequently true that soils of these types are well supplied with available phosphorus for a few years after being reclaimed but it must always be borne in mind that such soils are likely to show a deficiency in the available supplies of this element after a period of cropping unless barnyard manure or other fertilizer is used. The total amount of potassium in these soils is fair in all cases and large in some, but the chief question with reference to this element is not the total amount present, but conditions affecting its availability. While soils well supplied with vegetable matter as these usually are do not need special treatment with reference to potassium immediately after reclamation, they very generally do show a need of care in this regard within a few years, and patches of these types frequently fail to produce satisfactory crops even immediately after drainage and breaking unless barnyard manure or special potash fertilizer is supplied.

Owing to the fact that these soils receive the drainage from higher surrounding land the subsoil of which contains large

amounts of lime, they are as a rule well supplied with this substance and are not acid. Their lack of sufficient drainage limits their use for the growth of alfalfa or medium red clover to which otherwise they would be well adapted. These soils are, of course, usually well supplied with nitrogen—indeed they contain on an average from 3 to 5 times as much of this element as do the upland light colored silt and clay loam soils of this region. They do not therefore need special care with reference to this element and it is frequently more economical to use commercial fertilizers containing potassium and also phosphorus, where these elements are needed on such soils, and permitting the use of all the manure of the farm on the upland light colored soils which require nitrogen as well as the other elements.

In the improvement of these types the first question which should be given consideration is that of drainage.* The greater proportion of Clyde clay loam is not improved because of deficient drainage. While most of the Poygan clay is under cultivation crop yields are often much below the possibilities for this type because of the cold, wet condition of the soil in the spring and early summer. Plowing fields in narrow strips with dead furrows from 2 to 4 rods apart, and having these lead into open ditches along the side of the field will greatly assist in carrying off the surface water. In order to make the internal drainage of the soil complete, however, tile drains should be used to supplement the surface drains. From tests made by tile draining such land it has been found that the increased crops will pay for the improvement in the course of a few years.

When the drainage of these soils has been established and the crop yields still seem to be deficient, the question of applying commercial fertilizers should be considered. Ground rock phosphate should be applied at the rate of about 600 pounds per acre for the first application and from 300 to 400 pounds per acre once during each succeeding rotation. Muriate of potash may be applied for general farm crops, at the rate of about 150 pounds per acre. If cabbage or beets are to be grown from 250 to 300 pounds per acre should be applied. When these crops

* See Bulletin 339 Wisconsin Experiment Station—"The Right Drain for the Right Place".

are grown in rotation it may be unnecessary to use potash fertilizer in seeding down with a cereal crop following a crop on which a heavy application was used the previous year.

Rock phosphate may be applied at any time and should ordinarily be spread broadcast and either plowed in, disked, or harrowed in so as to have it well distributed through the soil. On account of the small bulk of the fertilizer used, it can be applied readily by hand, in seeding grain, or the potash and rock phosphate may be mixed and applied in the spring in one of the many fertilizer distributers on the market. Before using these commercial fertilizers over large tracts, however, it would be well to make tests on small plots to determine the need of the soil over any specific area, since there may be considerable variation due to drainage, the condition of the organic matter, etc.

Care must be exercised in the cultivation of these heavy soils, and they should be plowed only when the moisture conditions are the most favorable. Because of the large amount of organic matter present they are not as difficult to cultivate as Superior clay loam.

When these soils are thoroughly drained alfalfa and the clovers may be grown successfully, and the acreage devoted to these crops should be increased. Such crops as cabbage and sugar beets can be grown successfully, but the soils are too heavy for growing potatoes or the ordinary truck crops on a commercial scale. Such soils are best adapted to general farming and dairying, and these are the lines along which the greatest development is now being made.

CLYDE FINE SAND.

Description.—The material mapped as Clyde fine sand consists of a black fine to very fine sand, in places approaching a silt, underlain by a light colored, yellowish sand of nearly the same texture, and extending to a depth considerably below the 3 foot section.

Extent and distribution.—Clyde fine sand is of limited extent and confined to long narrow areas running parallel with or bordering the present shore of Lake Winnebago. Some of it is

within the city limits of Fond du Lac, and the total area is less than 2 square miles.

Topography and drainage.—The topography is level, the type occupying ridges only a few feet above the adjoining soils. The water table is close to the surface, and for this reason crops do not suffer during times of drought. The soil is sometimes excessively moist following spring rains.

Origin.—The type represents a beach deposit which was formed when the lake was at a higher level than at present.

Native vegetation.—The timber growth was scattering and consisted chiefly of elm, soft maple and a little ash.

Present agricultural development.—Within the city limits of Fond du Lac this type is used for building lots and garden patches. Outside of the city it supports some trucking with good results. Some of the general farm crops are also grown.

Method of Improvement.—Where this type is situated so that it can be cultivated it should be devoted to truck crops rather than to general farming. In most cases the natural drainage is sufficient. The type will respond to applications of rock phosphate and muriate of potash, and these fertilizers should be used in preference to stable manure, since the supply of organic matter is usually sufficiently large. On account of its small extent the type is of little importance from an agricultural standpoint.

POYGAN FINE SANDY LOAM.

Description.—The surface soil of Poygan fine sandy loam consists of a dark brown to black fine sandy loam, about 12 inches deep. In many places this is underlain to a depth of 24 to 48 inches by a reddish brown sandy clay, which in turn rests upon a red clay. The subsoil is, however, variable, and in some places consists of gravel mixed with yellowish clayey sand resting on red clay. The gravelly stratum varies in thickness from a few inches to several feet.

Extent and distribution.—Areas of this type are of small extent and confined to the basin surrounding Lake Winnebago. It all occurs just southwest of Calumetville, and the total area is less than 1 square mile.

Topography and drainage.—The topography is level to gently undulating and drainage over most of the type is well established. In spots where the clay lies near the surface tile drains could be used to advantage.

Origin.—The material from which the soil has been derived represents a glacial lake deposit. The red clay underlying the type is of lacustrine origin which may have been influenced to a limited extent by glacial action. The sandy portion of this soil appears to have been worked about to a greater or less extent by water action, and in places it appears to form old beach lines.

Native vegetation.—The original growth consisted of elm, ash, with some oak, and a few willows, with quite a heavy growth of grass where the tree growth was not dense.

Present agricultural development.—The greater part of Poygan fine sandy loam is cultivated, giving good yields of the general farm crops. Corn averages about 50 bushels, oats 40 bushels, barley 35 bushels, and rye 20 bushels per acre. The type is adapted to a wide range of crops.

Method of improvement.—As with the Clyde fine sand this type could probably be devoted to the production of truck crops to better advantage than growing general farm crops. It will respond to the same treatment as suggested for the Clyde fine sand, but because of its slightly heavier texture it is a somewhat better soil. Its limited extent makes it of little importance.

CHAPTER VI.

GROUP OF MISCELLANEOUS SOILS.

MIAMI SANDY LOAM.

Description.—The surface soil of Miami sandy loam consists of 10 inches of a yellowish-brown sandy loam of medium texture, rather loose structure, and having a relatively low content of organic matter. The subsoil consists of a medium textured sandy loam of a lighter yellow color than the soil. With increased depth the clay content increases until, at 18 to 26 inches, it is a sandy clay, which, in many places, is sticky. This layer of heavy material varies in thickness from 6 or 8 inches to several feet.

Miami sandy loam is subject to some variation, especially in the subsoil. At a depth of 24 to 30 inches a yellow or whitish fine to medium sand may be found. This sand contains little clay and sometimes extends below the reach of the auger, through another stratum of clay may be found at 3 feet, just below the stratum of sand. In the area in section 28, Auburn Township, there are a few small ridges, only a few feet in height, where there is considerable coarse material in the soil and subsoil and only a small quantity of clay in the subsoil. None of the variations are of sufficient importance to be mapped separately.

Extent and distribution.—The type is not extensive, there being only 2 square miles in the county. A small area is found northwest of Ripon, the remainder being confined to the southeastern part of the county in the townships of Osceola, Auburn and Ashford.

Topography and drainage.—The topography is undulating to gently rolling. Because of its sandy nature and the topography, the natural drainage is good, and there is never too much moisture in the soil. During dry seasons the type suffers somewhat from drought.

Origin.—The material from which Miami sandy loam has been derived consists of glacial debris, which covers practically the entire county. While the glacial drift contains considerable amounts of limestone material the surface of this type has been leached to such an extent that most of the carbonate of lime has been removed and the soil is sometimes found to be slightly acid in places.

Native vegetation.—The original forest growth on this type consisted of bur oak, white oak, with scattered maple, basswood, and birch. Nearly all of the timber of any value has been removed.

Present agricultural development.—All the general farm crops common to this region are produced from this type. Rye is grown to some extent. Corn yields from 30 to 35 bushels per acre, oats 25 to 30 bushels; barley is grown with fair yields, but does better on the heavier soils. Timothy and clover are grown for hay, yielding from 1 ton to 1½ tons per acre. Rye yields about 15 bushels per acre. Potatoes are especially well adapted to this type, being of good quality and yielding from 125 to 175 bushels per acre. Although alfalfa has been grown only in a few instances it has been found to do well.

The rotation of crops most commonly followed includes potatoes as well as corn, grain, and grass. Most farmers try to seed the land to grass every four or five years. Stable manure is applied to the sod at the rate of 10 to 12 loads per acre, although this amount is insufficient to supply the needs of the soil. A number of farmers sow rye for late fall pasture and plow it under in the spring as a green manure.

Chemical composition and improvement.—This soil contains a fair amount of phosphorus, which averages about 1000 pounds per acre in the surface 8 inches. The total potassium content is in the vicinity of 25,000 pounds per acre and this may be considered as a moderate amount. The supply of nitrogen is rather low and will average less than 2,000 pounds per acre. The first need of Miami sandy loam is an addition of organic matter which will increase the nitrogen content of the soil, and improve the water holding capacity. Wherever an acid condition has developed this should be corrected by the application of about 1200 pounds of ground limestone per acre. The sys-

tem of farming followed should be such as to permit the plowing under of a green manuring crop about once in every 3 or 4 years. This may well be a second crop of clover. If all available stable manure is used in conjunction with the green manuring crop the productivity of the soil will be materially increased. The limited extent of this soil makes it of only minor importance from an agricultural standpoint.

The price of land of this character ranges from $75 to $100 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of Miami sandy loam:

Mechanical analyses of Miami sandy loam.

Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Soil	0.3	3.3	29.7	41.2	2.0	16.8	6.6
Subsoil	.2	2.5	28.4	40.9	2.5	14.8	10.8

RODMAN GRAVELLY SAND.

Description.—The surface soil of Rodman gravelly sand consists of a yellowish-brown, loose, fine sand having an average depth of 6 inches. Considerable gravel is found upon the surface and mixed with the soil. The subsoil consists of a yellow fine sand, containing only a small percentage of silt and clay. The material frequently becomes coarser at 3 feet. In places the sand extends to a depth of 30 feet or more, and at irregular intervals layers of gravel are found.

Extent and distribution.—Only about one square mile of this type is found in the present survey. It is confined to the townships of Auburn, Osceola, and Ashford, where it occurs in a few scattered bodies. It is nearly always associated with Miami sandy loam, and occupies knolls and ridges from 20 to 40 feet higher than the latter type. The soil resembles the Rodman gravel, but the content of gravel is considerably smaller, and there is but little clay or other fine material present. Because

of its loose, open structure and its topography the drainage is excessive and the type droughty.

Topography and drainage.—Rodman gravelly sand occupies knolls and ridges from 20 to 40 feet higher than the surrounding country, and the topography ranges from bumpy to rolling. Because of the loose, open structure of the material and its topography the natural drainage is excessive, and the type suffers from drought during a portion of every growing season.

Origin.—Rodman gravelly sand is of glacial origin and consists chiefly of kame and esker material which was assorted by glacial waters and deposited beneath, or at the margin of, the ice sheet. Most of the gravel associated with this type is limestone, but on account of the large amount of leaching which has taken place the surface soil is sometimes slightly acid.

Native vegetation.—The original timber growth consisted chiefly of bur and white oak, but the stand was scattering and the growth somewhat stunted. A considerable proportion of the native timber is still standing, but it has little commercial value.

Present agricultural developments.—This is one of the poorest types in the county, and very little of it is under cultivation. During the spring and early summer some pasturage is afforded, but the grass dies down during the summer for lack of moisture. When the virgin soil is first cultivated there is some organic matter present, but after a few years it disappears and the surface has the appearance of a bare sand dune sprinkled with gravel. The land is usually abandoned after a few years' cultivation. Maximum yields on newly cleared areas are: Corn from 15 to 25 bushels; rye, 12 bushels; oats, 18 to 20 bushels; buckwheat, 12 to 15 bushels; and potatoes from 50 to 60 bushels per acre. The potatoes grown are of excellent quality.

Because of the droughty condition, loose, open structure, low organic matter content, and consequent poor yields obtained, this type has a very low value. It is doubtful if it can be cultivated profitably in its present condition. Before profitable yields could be expected it would be necessary to increase the organic matter content of the soil, and add to the mineral elements, phosphorus and potash, by the use of commercial fertilizers. This would be expensive. Probably the best use to which

such soil can be put is to seed to drought resistant grasses and pasture the land during the spring and early summer. The question of reforesting such land might well be considered.

RODMAN GRAVEL.

Description.—The surface soil of Rodman gravel consists of a yellowish-brown to dark-brown fine sandy loam, carrying a considerable quantity of gravel and extending to an average depth of 8 inches. The subsoil consists of a mass of sand, gravel, cobbles, and bowlders. Seams of sand several feet in thickness may occur in which there are no stones, while again there may be but little sand with the gravel. Stones and bowlders occur upon the surface and the structure of both soil and subsoil is loose and open.

Extent and distribution.—Rodman gravel is a small, unimportant type and occupies only one per cent of the land area of the country. It is found chiefly in the eastern and southeastern portions of the survey, though a few small patches occur also in the western part of the county.

Topography and drainage.—This soil occurs as narrow ridges, kames, and eskers, and where these are clustered together the topography would be classed as hummocky or choppy. On account of the loose, open structure of the material and the topography, the drainage is excessive and the soil is very droughty.

Origin.—The material forming Rodman gravel consists of glacial debris which has been assorted by glacial waters and deposited beneath, or at the margin of the ice sheet. The gravel in the soil consists largely of limestone, and doubtless a considerable proportion of the fine material has also been derived from limestone rock.

Native vegetation.—The original timber consisted chiefly of bur and white oak, but the growth was scattering and stunted. Some of original timber still stands but it has a very low commercial value.

Present agricultural development.—Rodman gravel is one of the poorest types mapped and may be considered nonagricultural. During spring and early summer it supports a fair

growth of grass, but later this dries up, unless the rainfall is heavy, as the soil is very droughty. A few small areas have been plowed and sowed to rye for pasture.

The gravel is used extensively for road building, and the sand and gravel make good concrete material. The bowlders provide material for building foundations.

CHAPTER VII.

MARSH SOILS.

PEAT.

(With included areas of Muck)

Description.—Under the term "Peat" have been included the low-lying areas where there has been a considerable accumulation of organic matter which is now found in various stages of decomposition. The layer of organic material varies in thickness from 1 to 10 feet or more. It may be a cinnamon-brown or dark-brown, fine, powdery material where well decomposed and dry, or a raw, fibrous mass where in the earlier stages of decomposition. By far the larger proportion of the Peat in this country lies between these two extremes, showing to some extent its fibrous nature, but having lost some of its original structure. Areas such as those found at the foot of Lake Winnebago and around Mullet Lake represent true marsh conditions, where there is a floating mass of vegetation, but where the accumulation has not proceeded far enough to result in the formation of beds of Peat. Included with the Peat areas are small patches of Muck, where the material is more thoroughly decayed and the content of mineral matter is higher. These areas are not of sufficient size to be shown on the map.

Extent and distribution.—Peat (with included areas of Muck) is distributed in areas of varying size throughout the county. The largest bodies lie in Marshfield, Forest, Osceola, Auburn, Eldorado, and Lamartine Townships, in each of which the type covers several square miles. The surface is level and the natural drainage is poor. But few efforts have been made so far to reclaim the land.

Topography and drainage.—The surface of the Peat marshes are level, low, and the natural drainage is very deficient. Up

to the present time but few efforts have been made to reclaim large areas of the Peat. On some of the marshes water covers the surface during the spring and early summer. In such places the surface is so soft during most of the summer that it will not carry the weight of farm animals.

Origin.—Peat (with included areas of Muck) has been formed in glacial lake basins, kettle holes, and ponded valleys. The decomposition of water-loving plants, retarded by the presence of water, has favored the accumulation of organic matter, which in time has formed the Peat. Two varieties of Peat beds were noted. Those derived from the decay of grasses and sedges are usually black in color, while those derived from mosses (chiefly sphagnum moss) are largely of a cinnamon-brown color.

Native vegetation.—The native vegetation on Peat (with included areas of Muck) varies. In the western part of the county there are, in addition to grasses, sedges, and mosses, some willow, elm, poplar, cattail, and other water-loving plants. To the east of the escarpment there are many areas covered with tamarack and white cedar. It is a noticeable fact that within Fond du Lac County there are no tamarack trees in the Peat areas west of the escarpment.

Present agricultural development.—With the exception of narrow strips along the edges of some of the marshes practically none of the Peat is used for agricultural purposes other than for pasture and hay. During the dry seasons nearly all of the marsh grass is cut for hay, but if the ground is saturated with water, it will not support the weight of a team. Many of the marshes are divided into small tracts and owned by farmers in the vicinity, who depend upon the marsh for hay when the usual supply from the upland fails, or is short.

CHEMICAL COMPOSITION AND IMPROVEMENT OF PEAT.*

Peat has been largely formed by the accumulation of vegetable matter, particularly sphagnum moss and certain sedges and grasses. It is very low in earthly matter, running from 80 to 95 per cent of organic matter. The amount of the mineral elements is consequently low, the total weight of phospnorus being

* Wisconsin Experiment Station, Bulletin 205, Management of Marsh Soils.

approximately 600 pounds per acre to a depth of 8 inches, and of potassium, 700 pounds. It will be seen, on comparison of these statements with those made on the composition of such soils as Miami silt loam and Fox silt loam, that the total amount of potassium, in particular, is extremely small, the amount in Peat often being less than 2 per cent. of that found in the upland silt loam soils. While the total amount is small, a large proportion of it is available to plants, especially if the surface has been burnt over, and the supply may be sufficient for from 1 to 3 crops. It is to be expected, therefore, that profitable cropping is possible over a long period of years, only by the use of some form of potassium fertilizer, either barnyard manure, wood ashes, or the usual commercial fertilizers containing this element. The total supply of phosphorus is rather low, though the difference between the amounts present in Peat and upland soils is very much less than in the case of potassium. In view of the enormous quantity of nitrogen contained in these soils, the average amount of which is over 15,000 pounds per acre 8 inches, it is unnecessary to use stable manure, the most valuable element of which is the nitrogen, so that, on farms including both Peat or Muck land and upland soils, the stable manure should be used on the upland, and commercial fertilizers containing phosphorus and potash, if needed, on the lower land, unless, indeed, there is sufficient manure for the entire farm, which is rarely the case. These marsh soils are rarely acid on account of the percolation of lime-containing water from higher lands, though occasionally patches of acid Peat are found on the larger marshes. This acidity, however, is not so detrimental in the case of marsh lands as in the case of sand and clay soils, since the chief objection to acidity is that it interferes with the growth of those legumes, such as clover and alfalfa, which are needed on the higher lands to secure nitrogen, but which are not needed on the marsh soils for this purpose, and to the growth of which, indeed, the marsh soils are not so well adapted physically.

In the improvement of Peat the question of drainage* is the first step to be considered. Both open ditches and tile drains can be utilized in reclaiming the marshy tracts. The major

* For special information concerning drainage, write the Soils Department of the Wisconsin Experiment Station.

portion of the Peat areas in Fond du Lac county can be profitably drained and improved. When properly handled the Peat will produce profitable crops of corn, alsike clover, timothy, and a number of other general farm crops, as well as special crops such as peppermint, celery, etc.

CHAPTER VIII.

GENERAL AGRICULTURE OF FOND DU LAC COUNTY.

Agriculture in the county dates back to 1837, when the first furrow was turned on the present site of Fond du Lac. Farming operations were started in the spring of 1839 at Waupun and five years later agricultural development was well under way in various parts of the county.

For many years wheat was the dominant crop, winter wheat being sown in the "openings," where there was more protection, and spring wheat on the prairies, from which the severe winds of winter blew the snow. After a few years winter wheat was almost entirely abandoned, and for a period of 25 years spring wheat was the leading crop. About this time the chinch bug, weevil, droughts, and lower yields somewhat discouraged the growing of spring wheat, and winter wheat came into favor again. Since then both winter and spring wheat have been grown, with the spring wheat in the lead, but the acreage devoted to this crop has rapidly decreased until at present there is less than 1,600 acres in wheat in the entire county.

Little attention was paid to rotation of crops during the early days, the same crop being grown on the land year after year until it was finally abandoned and new land taken up. As wheat growing declined corn was planted, and a more diversified system of agriculture resulted. Dairying gradually replaced wheat, and in 1870 the first dairyman's association in the State was formed. A cheese factory was erected in 1864. It is largely to dairy farming that the present prosperous condition of the region is due.

The type of agriculture most largely followed throughout the county at present is dairying, in conjunction with general farming and stock raising. The four leading crops of the area in the order of their acreage are oats, hay, barley, and corn. Wheat,

potatoes, alfalfa, rye, and a number of special crops are also grown, though much less extensively.

In 1909 the oat crop occupied an area of 72,551 acres, from which an average yield of slightly over 40 bushels per acre was obtained. In 1875 there were 21,966 acres, and in 1905 there were 62,325 in this crop. The Miami silt loam produces more oats than any other type of soil. Some of the crop is sold, but the greater part is fed to stock on the farms.

Hay is the second crop in point of acreage. The 71,031 acres in grass in 1909 was made up of about 40 per cent of mixed timothy and clover, 25 per cent of timothy alone, 7 per cent clover alone, 20 per cent marsh hay, with the remainder in alfalfa, tame grasses, and forage crops. The average yield of hay was 1.8 tons. Alfalfa is proving successful. From the 1,623 acres reported in this crop in 1909 an average yield of nearly 3 tons per acre was secured.

Barley is the third crop in importance in the area, 49,027 acres in 1909 yielding an average of 30.4 bushels per acre. The tendency at the present time seems to be to reduce the acreage given to this crop. During the early history of the region barley was not grown as extensively as wheat, oats, or corn, and in 1875 there were only 4,494 acres devoted to the crop. While some of the grain is fed on the farm the greater proportion is sold, and it may be considered the only cash crop grown extensively in the county.

Not as much corn is planted as one expects in a section where the dairy industry has been so highly developed. In 1909 there were 39,930 acres in this crop. The average yield for the same year was 40.8 bushels an acre. A large part of the corn is cut for silage. Corn matures satisfactorily in this latitude, and considerable attention is being paid to selecting and breeding the most desirable varieties. The Carrington silt loam is better adapted to this crop than any of the other types, and a relatively large proportion of the type is devoted to it. Practically all of the corn grown, except that sold for seed, is fed on the farm where it is grown, some as silage, some as a part of the grain ration for dairy cows and beef cattle, and a large part in fattening hogs.

The wheat harvested in 1909 from 1,581 acres averaged 21.4 bushels per acre. In 1875 there were over 90,000 acres in wheat,

while in 1905 there were 3,285 acres. It is no longer an important crop, and there are some communities where it is scarcely grown at all. Of the amount raised at present about one-third is winter, and two-thirds spring wheat.

Alfalfa is becoming an important crop, as its value as feed for dairy stock makes it a fine crop for this region. It has passed the experimental stage, and it is now recognized that it can be grown successfully in nearly all parts of the county. The average yield of hay is practically 3 tons per acre, three cuttings usually being obtained. Considerably higher yields are frequently secured, and four cuttings in a single season are not uncommon. An acid condition of the soil exists in some places, and this must be corrected before the best success can be attained with alfalfa.

A little rye is produced, but is confined chiefly to the sandy soils. In 1909 there were about 1,000 acres in rye, the average yield being 20 bushels per acre.

Potatoes are not grown on a commercial scale, except in the vicinity of Campbellsport, but many farmers produce more than are needed for home use, and the surplus is sold in the local markets. The acreage in potatoes in 1909 was 5,080 acres and the average yield about 168 bushels per acre.

Sugar beets are produced successfully on a nmber of different types of soil. Beets grown on the Miami silt loam have a slightly higher sugar content than those from the Carrington silt loam or the Clyde clay loam. Beets are grown more extensively on the first two types named than on any of the other soils of the county. Most of them are shipped to the factory at Menomonee Falls, Wis.

Peas for canning are grown extensively in the vicinity of Waupun, where a factory is located. Cabbage is also grown on a commercial scale in the same region. Cucumbers are extensively grown in the vicinity of Ripon, where a large pickling factory is located.

Trucking is carried on in the vicinity of Fond du Lac and the other important towns to supply the local markets, but no extensive areas are devoted to this type of farming. In the vicinity of Ripon and in a few other places considerable quantities of berries are grown with success.

While there are a number of small apple orchards in the area, the number of trees probably exceeding 60,000, this region is not considered to be within the portion of the State suited to the growing of apples on a commercial scale. This fact, however, should not prevent the planting of small orchards to supply the home with fruit.

Dairying is the most important type of farming followed in the county, and the one from which the largest income is derived by the farmers. The output is disposed of chiefly through creameries and cheese factories. In 1913 there were 30 creameries and 71 cheese factories in the county and more than 42,000 dairy cows. Among these are some of the most valuable cows in the country. There are a number of herds of pure-bred Holsteins, Guernseys, and Jerseys. The grade animals which form the majority of the herds throughout the county are gradually being improved by the use of pure-bred sires.

The growing of beef cattle and the feeding of beeves for the market is not carried on in an extensive way, but a few farmers make a specialty of raising this type of cattle. While many farmers feed some steers each winter, they are mostly of dairy breeds or their grades. The fat stock shipped out of the county goes to the Chicago market.

A farm which makes a specialty of raising pure-bred horses is located outside of Fond du Lac. On many of the farms all the work horses are raised and frequently there is a team to sell.

Hog raising is an important branch of farming in the area, and as carried on in conjunction with dairying it is very profitable. On the average about 25 hogs are turned off each year from 100 acres. The leading breeds are Poland China and Berkshire. Some Chester Whites and Duroc-Jerseys are also raised.

There are about 34,000 sheep in the county, and it is estimated that one farmer out of five raises sheep. The eastern and southeastern parts of the area are better adapted to this pursuit than the western parts.

While the majority of the livestock in the survey is of mixed breeding there are a considerable number of farms throughout the county which make a specialty of raising pure bred cattle, horses, sheep or swine. Frequently two or more classes of pure

bred stock are raised on the same farm. The sale of stock for breeding purposes frequently amounts to a considerable sum.

The benefits to be derived from a systematic rotation of crops are generally understood. In almost all parts of the county a definite rotation is practiced by the leading farmers, though not in every case the one best adapted to the conditions under which it is being used. Methods and rotation vary somewhat in different parts of the survey, but the rotation most commonly followed consists of corn one year, barley one, year followed by oats one year (these may be changed in order), with clover and timothy seeded in the last grain crop. The field is cut for hay one or two years and may be pastured one year after which it is manured and plowed again for corn. In the southeastern part of the county the land is so broken and many of the fields are so irregular in shape and variable in soil texture and adaptability that it is often very difficult to follow a definite system suited to all the conditions. The crop yields of most of the cash renters and the poorer farmers, where inferior methods are followed, are considerable lower than the yields obtained by the better farmers.

The Carrington silt loam, Poygan clay, and Clyde clay loam, where well drained, are better adapted to corn than the light-colored soils of the county. Small grains do best on the Miami silt loam. The grain is better in quality than on the black soils and there is not so much danger of lodging.

The methods of cultivation practiced are fairly well adapted to the conditions prevailing throughout the county at the present time. The large number of comfortable farmhouses, the large, well painted barns, well tilled fields, fine stock, and the generally neat appearance of the farms all indicate a condition of thrift and prosperity.

Among the weed pests found upon the farms in Fond du Lac County, Quack Grass, Canada Thistle, and Wild Mustard are probably the most troublesome. The loss due to weeds is frequently large and sometimes 25 per cent of the earning capacity of certain fields is being lost each year. "Fallowing, or cultivation without a crop, is the most certain method of eradication on large areas, and may be used to good advantage except on sandy soils and those continuously wet or very porous. Success depends upon the depth of plowing and frequent cultivation.

The prevention of all leaf-growth in weeds means their certain death. Certain cropping systems will usually be successful with Quack Grass.''*

The problem of labor is frequently a serious one and often influences agriculture to the extent of making the system of farming followed conform to the supply of labor. In several instances it is reported that farms have been sold because competent labor could not be secured. It seems especially difficult to get hired help that will take a sufficient interest in the care which must be given dairy cows. Many object to milking. Students from the agricultural college are sometimes secured for the summer months to work on the leading dairy farms. Farm hands usually receive $30 to $35 a month, with board, or about $400 per year, with a house and garden. Through haying and harvest time they are paid $2 a day.

Of the land in the area, 95.8 per cent is in farms, of which 72.5 per cent is classed as improved. The average size of farms is 105 acres. Of the farms in the county, 80.2 per cent are operated by the owners. Where land is rented the share system is the most common, though in some cases a cash rent is paid. Under the share system the tenant usually furnishes labor and work animals, one-half of the other stock and seed, and returns the owner one-half of the crops. Cash rents range from $3 to $6 an acre.

The agriculture of Fond du Lac County as a whole is highly developed and considerably above the average for the State. There are, nevertheless, some changes which would tend to increase the productiveness of the soil, add to the income of the farmers, and still further develop the area. Practically all of the light-colored soils of the county are deficient in organic matter, and the amount of stable manure produced is seldom sufficient to supply the amount of humus-forming material needed. To supplement this, green manuring crops should be grown more extensively than is the practice at present. A legume is best for this purpose.

* Extract from Circular 48 of the Wisconsin Agricultural Experiment Station on "How to Rid Our Farms of Weeds". This publication should be consulted for more specific and detailed information on the life-periods, habits, and methods of eradication of weeds.

An acid condition exists on many of the soils and before the maximum yields can be obtained this condition must be corrected. The acidity is much more pronounced in some sections than in others. Applications of 2,000 pounds of ground limestone per acre will be sufficient to neutralize the acids and keep the soil sweet for a number of years. The application of rock phosphate to some of the soils, especially Carrington silt loam, will undoubtedly increase the yields.

Alfalfa should be grown more generally. Every dairyman, at least, should grow this crop. When the soils are properly drained, limed, manured, and inoculated alfalfa can be successfully produced on all of the heavier types in the county. In many places inoculation will not be necessary, since sweet clover is found growing wild in various parts of the county, and where this plant occurs the soils are already supplied with the proper bacteria. Not more than an acre or two should be planted at first, the area being extended as the methods of handling are learned.

The cultivation of special crops, such as sugar beets, peas for canning, cabbage, cucumbers for pickling, small fruits, and the like, could be increased in various parts of the county to advantage.

The question of drainage is one which should be given careful consideration in Fond du Lac County. In the low-lying sections south and west of Fond du Lac there are thousands of acres which are producing fair crops each year, but which by the installation of tile drains could be made very much more productive. A large number of places in the Carrington silt loam could be improved by tiling and all the Clyde clay loam is deficiently drained. Up to the present time little tiling has been done in the county, but there is no question that it would be profitable. Land values are high and it is poor economy to have a part of a high-priced farm on a nonproducing basis. Besides the poorly drained soil mentioned there are a large number of marshes within Fond du Lac County, the drainage which constitutes a large problem. Such marshes, when properly drained, can be made to yield profitable crops, and their reclamation should be encouraged.

CHAPTER IX.

CLIMATE.*

"Among the factors which influence the agriculture of a state, none is more important then the climate. The class of crops which can be grown is largely determined by the length of the growing season, and the amount and distribution of the rainfall". Anyone of these factors may determine the type of agriculture which can be practiced to best advantage.

"The distribution of the rainfall over Wisconsin is remarkably uniform, the average yearly percipitation having a range of from about 28 to 34 inches, while the mean for the State as a whole is 31 inches. This is a slightly heavier rainfall than is received by eastern England, northern France, most of Germany, Sweden, and the Dundee Valley. As compared with other portions of this country, Wisconsin has a total rainfall equaling that of central Oklahoma and Kansas, northern Iowa, Michigan, northwestern New York, or the Puget Sound Basin of Washington. But owing to its northerly location the lessened evaporation probably makes the precipitations as effective as that of Arkansas, Illinois, or Virginia."

"The local distribution of rainfall varies, however, from year to year, some sections receiving more rainfall one year, and other sections more in other years. The variation is caused by the movement of cyclonic storms." The average rainfall for the entire State during the driest year was 21.4 inches and for the wettest year 37 inches.

"Of equal importance in agriculture, to the total rainfall, is its seasonal distribution, and in this respect Wisconsin is unusually fortunate, since about half of the total rainfall comes

* This chapter has been based largely upon, and the quotations indicated have been taken from, Wisconsin Bulletin 223 on "The Climate of Wisconsin and Its Relation to Agriculture". This bulletin should be consulted for more information on the subject.

in May, June, July, and August, and nearly 70% from April to September, inclusive. June has the heaviest rainfall, averaging 4.1 inches, while July averages 4 inches and May 3.9 inches. The precipitation during the winter, on the other hand, is slight; December, January, and February each averaging from 1 to 1.5 inches of rain and melted snow. The average railfall for the State during winter is 3.9 inches, during spring 8.3 inches, during summer 11.4 inches and during Autumn 7.4 inches." Most of the rainfall occurs just preceding and during the period of plant growth, thus being received by the crop at the most effective time. "Wisconsin receives during the growing season, April to September inclusive, an average of 21 inches of precipitation, which is as much rain as that received during the same months by eastern Texas, Illinois, Ohio, or eastern New York. The small winter precipitation in Wisconsin, mostly in the form of snow, on the other hand, causes virtually no leaching of fertility from the soil, or erosion."

Another phase of rainfall distribution of great importance is its variation within a period of a few weeks. Frequently periods of drought and periods of unusually heavy rainfall occur, continuing for one to four weeks, but occasionally longer. Observations taken at Madison by the Weather Bureau over a period of 30 years from 1882 to 1911, inclusive, show that there are on the average three ten day periods during each growing season when the amount of rainfall is so slight that crops on a reasonably heavy soil (Miami silt loam) actually suffer from the lack of moisture. In Fond du Lac County where most of the soils are of the same texture conditions would be very similar.

Fond du Lac County lies mostly within the Fox River Basin, which, with the Wolf River Basin, is recognized as forming one of the eight climatic provinces in Wisconsin. "This region has an intermediate climate, partaking some of the influence of Lake Michigan but exhibiting more of the features of a land climate. The winters at Green Bay, Appleton, Pine River,* Oshkosh, and Fond du Lac, with a mean temperature averaging 18.7°, are as warm as those at Dodgeville or at Lancaster, while the springs (43°) and the summers (68°) are as cool as the average

* Located in Leon Township, Waushara County.

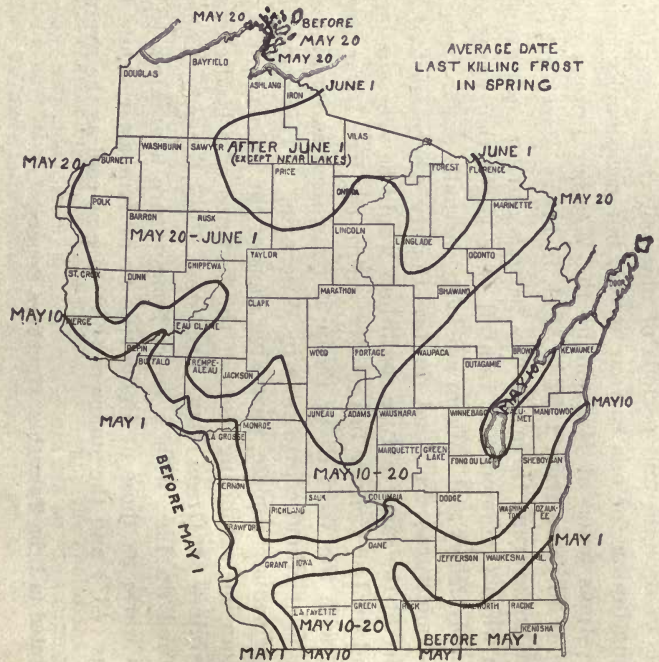


FIGURE 1. LAST KILLING FROST IN SPRING.

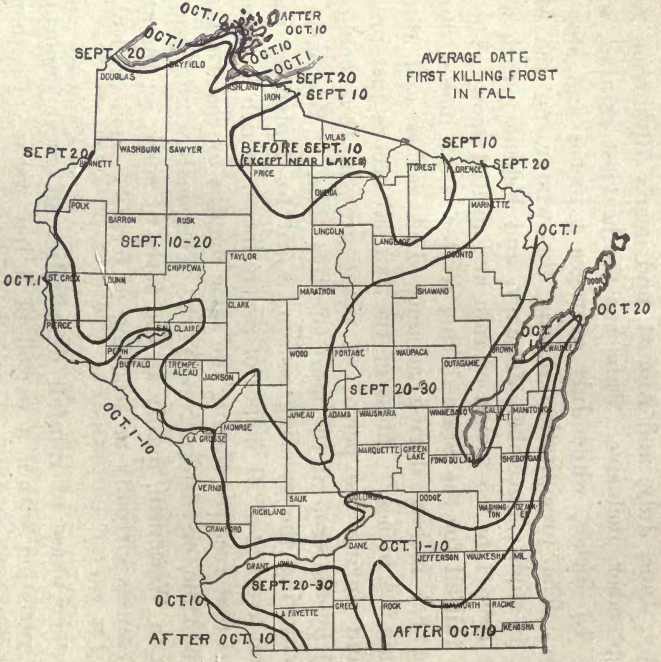


FIGURE 2. FIRST KILLING FROST IN FALL.

These maps have been prepared from the original monthly reports of the observers of the U. S. Weather Bureau for the past 12 years, supplemented by private records.

of Eau Claire and Osceola. The growing season of 130 to 150 days, however, shows the land influence, being of about the same length as Richland, Buffalo, and St. Croix counties, Wisconsin; or Cattaraugus, Chenango, and Deleware counties, New York; Center and Lycoming counties, Pennsylvania; northern Iowa; or central Utah. The rainfall (29.6 inches) in this region is possibly a little less than elsewhere in the State."

By reference to figures 1 and 2, it will be observed that the average date of the last killing frost in the spring in the region including Fond du Lac County is between May 10 and 20. The average date of the first killing frost in the fall in the same region is between September 20 and 30, except in the immediate vicinity of Lake Winnebago where the average date of the first killing frost in the fall is October 10. As indicated by the Weather Bureau Records taken at Fond du Lac the average length of growing season at that point is 150 days, and this may be taken as being fairly representative for the area surveyed. From the data given on the two accompanying maps, the length of growing season for any portion of the State may be readily determined.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation as recorded by the Weather Bureau station at Fond du Lac and covering a period of years from 1886 to 1909:

Normal monthly, seasonal, and annual temperature and precipitation at Fond du Lac.

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*
December	21.8	57	—27	1.48	1.44	1.10
January	17.0	54	—44	1.50	1.34	2.36
February	17.9	56	—30	1.13	0.34	2.00
Winter	18.9			3.91	3.12	5.46
March	31.0	75	—16	1.63	0.49	0.82
April	44.5	87	— 5	2.24	0.97	1.79
May	56.1	91	23	3.24	2.45	6.86
Spring	43.8			7.11	3.81	9.47
June	66.0	96	31	3.53	0.69	8.31
July	70.0	102	40	3.53	2.15	4.56
August	67.7	100	35	3.44	3.19	1.59
Summer	67.9			10.20	6.03	14.46
September	61.2	96	22	2.86	1.05	2.46
October	48.5	89	8	2.05	0.31	1.03
November	33 7	68	—14	1.71	1.17	1.46
Fall	47 6			6 62	2 53	4.95
Year	44.6	102	—44	27.84	15.59	34 34

As indicated by the above table the mean annual temperature at Fond du Lac is 44.6°, the maximum 102°, and the minimum —44°. The average rainfall is 27.84 inches, which, under normal conditions, is well distributed throughout the growing season. The months of May, June, July, and August, during which the crops are most in need of a good supply of moisture, have an average of more than 3 inches of rainfall.

While there is a wide range in the temperature, the extremely low and high readings recorded are rare and the periods affected are of short duration. The winters are usually severe and there

is an average snowfall of 28.7 inches. The prevailing winds are from the southwest.

The climatic conditions which prevail in Fond du Lac County are representative of a large section in the east-central part of the State, where agriculture is highly developed and where extremes of climate do not prevent the growing of any of the general farm crops. Excellent water for household purposes and for stock can be readily obtained in all portions of the county. This fact, together with healthful climatic conditions, length of growing season, and rich, productive soil, places Fond du Lac County in a class with the most desirable agricultural communities in Wisconsin.

SUMMARY.

Fond du Lac County is located in the east-central portion of the State of Wisconsin and comprises an area of about 734 square miles, or 469,760 acres. The county has a population of 51,610. The city of Fond du Lac, with a population of 18,797, is the county seat, an important railroad and manufacturing center, and the largest local market in the county.

Three important railroad systems enter the county and provide excellent transportation facilities. Fond du Lac is 159 miles from Chicago over the Soo Line.

The soils of the county are all derived from glacial and lacustrine material and owe their differences largely to the varying agencies of deposition and to the character of the morainic topography in which they are found. Seven distinct soil series and 15 soil types were recognized and mapped.

Of these the Miami is the most extensive and important series. The silt loam is the most important type of the series. It is a good general farming soil and well adapted to all the farm crops common to the region. The gravelly loam, where sufficiently deep, produces yields nearly equal to the silt loam, but the shallow areas suffer at times from drought. It is considered a fair soil. The Miami sandy loam is of small extent and found chiefly in the southeastern part of the county.

The Fox silt loam is a good general farming soil and all the ordinary farm crops of the region are grown upon it.

The Rodman gravelly sand and Rodman gravel are of limited extent and of little importance agriculturally.

The Superior series is derived from both lake-laid and ice-laid material, and is represented here by two types. The clay loam, with its rolling phase is quite extensive, highly developed, a good general farming soil, and well adapted to dairying. Portions of

it should be tile drained. The gravelly loam is of limited extent and of little importance agriculturally.

The Poygan series is closely associated with the Superior soils and is of the same origin, but the deposits have been modified by the accumulation of organic matter. The clay is naturally a productive type, and yields on it could be materially increased, and all the type brought to a high state of cultivation if tile drains were generally installed. The fine sandy loam is of very small extent.

The Carrington series embraces the dark-colored, glacial prairie soils. Some of the most highly developed land of the State is composed of these soils. The silt loam type is extensively developed in the western part of the county. It is a good general farming soil and supports a well-developed dairy industry. Portions of the type are in need of tile drainage and applications of lime. The gravelly loam consists of small knolls and rounded hills over which the soil is shallow and often filled with limestone fragments.

The Clyde series occupies old lake beds, ponded valleys, and other minor depressions, in which there is an accumulation of some organic matter, but not enough to give a Muck or Peat. The clay loam is in need of drainage. When properly drained it will make a very productive soil. The fine sand represents an old shore line of Lake Winnebago. It is of small extent and of little importance.

Peat (with included areas of Muck), essentially an organic soil, occupies old lake beds, ponded valleys, and the valleys along streams. It is all poorly drained, and but few attempts have been made to reclaim it.

Dairying, in conjunction with general farming, is the type of agriculture most extenvisely followed at present. The products are chiefly butter and cheese. The leading crops are oats, barley, corn, and hay. Alfalfa is being successfully grown and the acreage is increasing. Wheat and rye are raised to a limited extent. Such special crops as potatoes, sugar beets, cucumbers, cabbage, and peas for canning are successfully grown, though not on a very extensive scale.

Of the land in the county 95.8 per cent is in farms and of this 72.5 per cent is improved. The average size of farms is 105 acres and 80.2 per cent of all farms are worked by the owner.

Agriculture in Fond du Lac County, as a whole, is highly developed. The extension of tile drainage and the use of lime in some form are suggested steps for further improvement.

The mean annual temperature is 44.6°, the rainfall 27.84 inches, and the snowfall 28.7 inches. The winters are severe, but the growth of all vegetation during the summer months is rapid. The average length of the growing season is 150 days.

KEEP THE MAP.

The Experiment Station will publish bulletins from time to time dealing with the management of the different types mapped, so that some way should be found by each person receiving a copy of this report to keep the map permanently. If the map is folded in such a way as to have the part you are interested in of a convenient size, and then have a simple frame with glass made to hold it, it can be kept indefinitely. Since some of the colors fade after being exposed to strong light for a long time, it would be a good plan to have a protecting flap of dark cloth over the map when not in use.